REPORT RESUMES

ED 013 099

JC 670 801

DEMAND FOR ENGINEERS AND TECHNICIANS--1966.
BY- ALDEN, JOHN D. AND OTHERS
ENGINEERING MANPOWER COMMISSION, NEW YORK, N.Y.

PUB DATE NOV 66

EDRS PRICE MF-$0.50 HC-$3.80 95P.

DESCRIPTORS- *JUNIOR COLLEGES, *ENGINEERS, *TECHNICAL OCCUPATIONS, SUBPROFESSIONALS, *ENGINEERING RELATED TECHNOLOGY, *EMPLOYMENT OPPORTUNITIES, TECHNICAL EDUCATION, OCCUPATIONAL SURVEYS, EMPLOYMENT TRENDS,

A QUESTIONNAIRE SURVEY TO ASSESS THE NATURE AND LEVEL OF CURRENT AND FUTURE EMPLOYMENT OF TECHNICIANS BROUGHT RESPONSES FROM 490 ORGANIZATIONS EMPLOYING SUCH PERSONNEL. THE RECENT DEMAND FOR BOTH GRADUATE ENGINEERS AND ENGINEERING TECHNICIANS HAS BEEN GROWING, AND THE TREND WILL PROBABLY CONTINUE. THE RAPID GROWTH AND UPGRADING OF TECHNICAL PROGRAMS IN JUNIOR COLLEGES AND TECHNICAL INSTITUTES ARE CONTRIBUTING TO BOTH THE DEMAND FOR AND THE SUPPLY OF TECHNICIANS. THE SHORTAGE OF GRADUATE ENGINEERS WILL PROBABLY RESULT IN MORE EFFECTIVE UTILIZATION OF THE AVAILABLE PERSONNEL AND INCREASED EMPLOYMENT OF TECHNICIANS TO PERFORM THE MORE REPETITIVE TECHNICAL OPERATIONS. IN A 1-YEAR PERIOD, THE NUMBER OF TECHNICIANS PER 100 ENGINEERS AND SCIENTISTS INCREASED FROM 38 TO 42. THIS DOCUMENT IS AVAILABLE FOR $4.00 FROM ENGINEERING MANPOWER COMMISSION OF ENGINEERS JOINT COUNCIL, 345 E. 47TH ST., NEW YORK, N.Y. 10017. (HH)

ERIC

ED013099

DEMAND

FOR ENGINEERS AND TECHNICIANS—1966

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

UNIVERSITY OF CALIF.
LOS ANGELES

SEP 5 1967

CLEARINGHOUSE FOR
JUNIOR COLLEGE
INFORMATION

a survey conducted by the
ENGINEERING MANPOWER COMMISSION
OF ENGINEERS JOINT COUNCIL

JC 670 801

DEMAND
FOR ENGINEERS AND TECHNICIANS–1966

ENGINEERING MANPOWER COMMISSION
of Engineers Joint Council

345 E. 47th Street
New York, N.Y. 10017

NOVEMBER, 1966

PRICE: $4.00

Engineering Manpower Commission of Engineers Joint Council

The Engineering Manpower Commission of Engineers Joint Council is charged with the responsibility of developing programs to:

1. Aid in establishing the importance of engineering to the national economy.
2. Aid in maintaining an adequate supply of engineers.
3. Promote the most effective utilization of engineers in support of the national health, safety, and interest.

EMC OFFICERS

Chairman........................Clifford H. Doolittle
Vice Chairman, and
Chairman of Surveys Committee.........Donald E. Irwin

This study was prepared by John D. Alden, Executive Secretary of the Engineering Manpower Commission. Data were compiled by Joseph Horn, the report was typed by Beatrice Cochrane, and most of the tables were typed by Carol Iceland. The help of many who submitted comments and suggestions is gratefully acknowledged, with particular thanks to Donald E. Irwin and Arthur F. Dershowitz, of the EMC Surveys Committee.

ENGINEERS JOINT COUNCIL MEMBERSHIP

•

CONSTITUENT SOCIETIES

AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
AMERICAN WATER WORKS ASSOCIATION
THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS
AMERICAN SOCIETY FOR TESTING AND MATERIALS
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
AMERICAN SOCIETY FOR METALS
THE SOCIETY OF AMERICAN MILITARY ENGINEERS
THE AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS

•

ASSOCIATE SOCIETIES

AMERICAN INSTITUTE OF CONSULTING ENGINEERS
AMERICAN INSTITUTE OF PLANT ENGINEERS
AMERICAN ASSOCIATION OF COST ENGINEERS
NATIONAL INSTITUTE OF CERAMIC ENGINEERS
SOCIETY OF WOMEN ENGINEERS
SOCIETY OF FIRE PROTECTION ENGINEERS

•

AFFILIATE SOCIETIES

AIR POLLUTION CONTROL ASSOCIATION
SOCIETY FOR NON-DESTRUCTIVE TESTING
INSTRUMENT SOCIETY OF AMERICA
AMERICAN SOCIETY FOR QUALITY CONTROL
CONSULTING ENGINEERS COUNCIL

•

REGIONAL AFFILIATE SOCIETIES

WESTERN SOCIETY OF ENGINEERS
MICHIGAN ENGINEERING SOCIETY
ENGINEERING SOCIETY OF CINCINNATI
LOUISIANA ENGINEERING SOCIETY
NORTH CAROLINA SOCIETY OF ENGINEERS
WASHINGTON SOCIETY OF ENGINEERS
ENGINEERING SOCIETIES OF NEW ENGLAND
SOUTH CAROLINA SOCIETY OF ENGINEERS
LOS ANGELES COUNCIL OF ENGINEERING SOCIETIES
HARTFORD ENGINEERS CLUB
AMERICAN MATERIAL HANDLING SOCIETY (NEW JERSEY CHAPTER)
CHINESE INSTITUTE OF ENGINEERS

Contents

Chapter		Page
1.	Why a Demand Survey?	9
2.	How the Survey was Conducted	12
3.	Results in Brief	15
4.	A Survey Parallel	24
5.	The Demand for Engineers	27
6.	The Demand for Technicians	51
7.	A Look at Supply	63
8.	Appendix	73
9.	Questionnaire Form	91

Tables and Charts

Tables		Page
1.	Growth in Engineering Employment, 1964-1966	28
2.	Engineering: Growth in Total Employment, 1951-1965	29
3.	1966 Engineering Recruitment Picture Compared to 1965	32
4.	Long-Range Growth in Engineering Employment to 1976, by Activity	36
5.	New Graduate Hires Per 100 Employed Engineers	40
6.	Future Trends - Percent of Respondents Who Believe the Proportion of Engineers at Various Degree Levels Will Change as Indicated Over the Next Decade	43
7.	New Hires from Specific Curricula, Current and Future - Percentages for 1966/1976	44
8.	Percentage of 1966 Openings Which Could be Filled by People With Various Alternative Educational Qualifications	47
9.	Engineering Separations - 1965	48
10.	Growth in Technician Employment, 1964-1966	52
11.	1966 Technician Recruitment Compared to 1965	54
12.	New Hires of Technical Institute Graduates, 1964-1976	58
13.	Future Trends - Percent of Respondents Who Believe the Composition of Technician Staffs Will Change as Indicated Over the Next Decade	60
14.	Technician Separations - 1965	62
15.	Engineering Enrollments and Degrees	66
16.	New Graduate Engineers Available for Employment Each Year	68
17.	New Entrants from Post-Secondary Pre-employment Technician Training Programs, 1963-1974	71

Charts

Page

A. Projected Growth of Engineering Employment, 1965-1976........... 33

B. Predicted Employment of Engineers by Selected Respondent Activities, 1964-1976.................................... 34

C. Projected Growth in Technician Employment, 1965-1976............ 56

D. Engineering Freshmen Enrollments and First Degrees.............. 67

E. Master's and Doctor's Degrees in Engineering.................... 67

Appendix Tables

I. Engineering: New Hires, Separations, and Total Employment-1964.. 76

II. Engineering: New Hires, Separations, and Total Employment-1965.. 77

III. Engineering: New Hires, Separations, and Total Employment - 1966 (Estimated)....................................... 78

IV. New Graduate Hires - Bachelor's Degree, 1964-1976.............. 79

V. Engineering Hires by Curriculum, 1966........................... 80

VI. Estimated Engineering Hires by Curriculum, 1976................. 81

VII. Engineering Separations - 1964................................. 82

VIII. Engineering Separations - 1965................................. 83

IX. Technicians: New Hires, Separations, and Total Employment-1964.. 84

X. Technicians: New Hires, Separations, and Total Employment-1965.. 85

XI. Technicians: New Hires, Separations, and Total Employment - 1966 (Estimated)....................................... 86

XII. Long-Range Growth in Technician Employment to 1976, By Activity.. 87

XIII. Ratio of Technicians to Engineers and Scientists................ 88

XIV. Technician Separations - 1964................................... 89

XV. Technician Separations - 1965................................... 90

1 Why a Demand Survey?

INTRODUCTION

Continuing assessment of the nation's engineering and technological manpower resources is one of the basic objectives of the Engineering Manpower Commission. Since the Commission's organization in 1950, the growth of the nation's economy, the rapid advances of science and technology, and changing requirements for national defense have reflected themselves in the demand for manpower. Indeed, it is becoming more and more apparent that skilled manpower is probably the limiting resource in today's technological world. The utilization of this scarce resource in the face of competing demands is a major challenge to which no easy solution exists.

Since 1951, the Engineering Manpower Commission has been conducting surveys of the demand for engineers. Other agencies, notably the National Science Foundation, have also made large-scale projections of supply and demand. As might be expected, each survey has produced different estimates of how much manpower will be needed and in which areas of technology the need will be greatest. One feature has stood out in all of these surveys, however, namely that the demand appears to be greatly in excess of the projected supply of formally educated engineers, scientists. and technicians. In the arguments back and forth over methodology, many have lost sight of the fact that the differences are ones of degree but not of direction. The important thing is that the projected supply of college graduates will be insufficient to meet any of the demand figures projected in recent years.

Demand is a particularly difficult quantity to measure. What constitutes demand? Few would agree on a definition. To some, it means job vacancies, but even here it is difficult to decide when a vacancy really exists. Many companies have large numbers of "vacancies" which they do not really expect to fill in the immediate future. There are others who say that demand is the difference between the number currently employed and the number which companies would like to have. Still others would equate demand with those requirements needed to fulfill firm plans for the future--new mines coming into production or new plants on the drawing board. One well-known "demand index" is based solely on recruiting activity as measured in the advertising columns of newspapers and magazines. The subject of demand is so complex that a recent international conference spent days on it without doing much more than familiarize the attendees with each other's limitations.[1]

In approaching the subject of demand it is helpful to adopt the economist's approach--supply and demand must be equal by definition. One may wish or expect what he likes for any time in the future, but at any actual time supply and demand are going to be equal. The way in which they equalize is by adjustments on both sides of the equation. The supply can be increased by attracting people from other fields by offering them higher salaries and benefits, by retraining and upgrading employees, by working overtime and delaying retirement, and by other similar means. Demand can be reduced by redefining jobs so that they can be done by people of lower skill, by shifting priorities of projects, by automation, etc. Rosy hopes of future expansion fade under the realities of the present, and employers "make do" with what they have.

Viewed in this light, future "demand" (whatever this may be) is something which can and must be constantly changing. One of the biggest unknowns is always what to expect of the nation's overall economy. Estimates of employment five or ten years in the future are obviously tempered by considerations which cannot be predicted reliably and are beyond the control of the individual or company making the prediction.

Because of these difficulties, there are many who sincerely believe it is futile to attempt predictions of future demand. Frequently they feel that great harm is done because of exaggerated interpretation of demand fluctuations and "scare" stories in the press. Such things undoubtedly cause much unnecessary alarm and may even deter a few young people from engineering careers which they might otherwise have chosen. The Engineering Manpower Commission, however, recognizing the difficulties involved in measuring demand and the dangers of possibly unfavorable reactions to its findings, firmly believes that estimates of the supply and demand for engineers are essential in planning for the future of

[1] National Bureau of Economic Research, *The Measurement and Interpretation of Job Vacancies.* New York: Columbia University Press, 1966.

the profession. We cannot ignore the problem simply because we know our solutions will not be perfect.

Our method of assessing demand is based on the assumption that personnel executives in industry, government, and education are in the best position to understand and evaluate present and future factors affecting their own organizations. By classifying and summarizing data reflecting the judgments of many such individuals, we believe we can provide useful information regarding the nature and level of current and future employment of engineers and technicians.

Definitions

ENGINEERS - Engineers in this survey are defined as engineering graduates (employed in all activities, including supervision and management, or men lacking an engineering degree, but whose experience and training permit them to hold positions normally requiring such a degree.

PHYSICAL SCIENTISTS - The term includes employees with a baccalaureate or higher degree in the fields of chemistry, physics, earth sciences, and mathematics.

TECHNICIANS - Individuals who work with engineers and physical scientists having technical training beyond high school, normally consisting of two years full time formal instruction in a technical institute, or equivalent industrial training or experience.

GROWTH - As used in this report, growth refers to the increase in the employment of, or the demand for, engineers and technicians, whether expressed in absolute quantities or as percentages.

SEPARATIONS - This refers to the gross numbers of engineers or technicians leaving the employ of the reporting company because of death, retirement, resignation, discharge, or similar reason.

2 How the Survey Was Conducted

The 1966 demand survey is based on questionnaires returned by 490 organizations employing, in 1966, more than 298,000 engineers, technicians, and physical scientists. Within this total group are 183,000 engineers, 74,000 technicians, and 40,000 physical scientists. Because not all respondents answered every part of the survey, the actual numbers will vary somewhat from question to question. The sample represents approximately 26% of the 700,000 professional-level engineers which EMC estimates are employed in the United States today.[1]

The questionnaire, which is reproduced on pages 91 to 96, was mailed in March and April of 1966. Returns were tabulated starting in June 1966 and analysis was begun as soon as data became available.

The 1966 questionnaire expanded the investigation of engineers and technicians by asking several new questions, designed to answer, both qualitatively and quantitatively, the following:

> How does the immediate demand, as reflected in current recruitment conditions, compare with last year?
>
> What is the projected growth during the next decade?
>
> What industries show the greatest requirements for engineers and technicians?
>
> What are the trends in demand for the various levels of education?
>
> What curricula are most in demand, and how firm is the demand for specific specialists?

---

[1] *Engineering Manpower Bulletin No. 5,* Engineering Manpower Commission of Engineers Joint Council. July 1966.

The section on physical scientists was reduced to a nominal set of questions, permitting comparison of the numbers of these scientists relative to engineers and technicians in the same industry. This was done because it was recognized from past surveys that the group of employers surveyed, although intended to be representative of engineering employment, was probably not a true cross section of the employment of scientists. Rather than attempt to develop another sample for physical scientists, it was decided to concentrate on engineers and technicians as already noted.

The returned questionnaires were separated into groups by type of employer and the results tabulated by hand, a laborious task. Because we are, in effect, trying to average a large number of estimates or opinions, weighting factors have been applied to all the purely qualitative replies by multiplying each reply by the appropriate number of engineers employed or hired. For example, in the question comparing recruitment this year with last, each employer's reply was given a weight equal to the number of engineers actually hired. Thus a company reporting that recruitment was more difficult on the basis of 100 new hires would not be counteracted by another reporting that it had found no difficulty in recruiting one or two new engineers.

In most of the tables, figures for all respondents, all industry, and all government were obtained by simply adding up all responses in those general categories. This is the method used in previous surveys. Its major drawback is that it does not compensate for different rates of response by the various groups included in the broader categories. Statistics obtained in this way are labeled "unadjusted". They should be viewed only as general indicators. A glance at the individual activity groups will indicate the danger of attempting to generalize for "all industry" or "all government", since radically different, even conflicting, trends may be at work in the separate components.

In order to sum up individual figures into an overall estimate of total engineering demand, several of the questions were adjusted by applying weighting factors based on the percentage of total engineering employment accounted for by each industry or other activity. Special estimates for this purpose were developed by Engineering Manpower Commission using basic data from the Bureau of Labor Statistics of the U.S. Department of Labor. The effect of this adjustment was to compensate for variations in the response rate among the different industries participating in the survey. We do not believe that this procedure is sufficient to convert our sample data into a completely representative picture of national engineering employment. There are far too many unknowns in the available statistics for any survey taker to be certain that he has chosen a sample representative of the universe he is seeking to study, or that the particular respondents to his questionnaire are actually typical of the industry or other activity they represent. We have, however, minimized the possibility of giving undue weight to those industries from which we received a large number of responses.

Summary statistics which were weighted in this way are labeled "adjusted". (See Appendix, page 73 for a detailed description of the methodology used.)

3

Results in Brief

THE GENERAL PICTURE

In the two years since the last EMC demand survey, engineering employment has gone through a period during which a few well-publicized contract cancellations and other regional dislocations created an impression of sharply reduced demand. This was soon dispelled by indications of a growing shortage of engineers and technicians. Recruiting activity reached record high levels in the spring and summer of 1966. The U. S. Department of Labor statistics, for the first time in the eight years the current series has been published, showed more engineering openings than applicants registered with the public employment offices. College placement officials and company recruiters alike have reported that campus recruiting activity this year was at a record pitch. It seems apparent that the long-range factors behind the country's economic growth are continuing to generate a growing demand for engineers in the decade ahead.

The supply outlook promises a continuing shortage in the numbers of engineers and technicians available for employment. The competition among curricula for qualified students has resulted in a steady decline in engineering enrollments as a percentage of the entering freshman class. Other professions report similar difficulties in recruiting new students. Thus, despite the great increase in the number of students entering college, engineering enrollments and degrees are growing much more slowly, if at all.

In the technician field there is some prospect of a substantial increase in the number of graduates, but this will not make much of a splash in the tremendous technician manpower pool which today is composed preponderantly of people whose training was mostly received on-the-job.

ENGINEERS

Employers envision a growth in engineering employment of about 3% per year for the next decade. Actual growth in 1964-1966 was about 7% per year, so that future predictions show a definitely conservative trend.

The demand for new college graduates averages out to 69,000 per year, in contrast to an estimated supply of about 41,000.

Recruitment of all kinds of engineers was more difficult this year than last, with new bachelor's degree graduates the hardest of all to hire. Even nongraduates were relatively difficult to find.

Employers generally expect the proportion of master's and doctor's degree holders to increase, and that of nongraduates to decrease. They indicate a great deal of flexibility in being able to meet their requirements, in many instances being willing to accept graduates of scientific or other curricula or even nongraduates in lieu of engineers.

Separations were at the lowest rates reported since 1960, running between 6% and 7% of total employment. Discharges and layoffs were down to 0.5%, and armed forces calls accounted for 0.2%.

TECHNICIANS

A growth in technician employment of a little over 3% is envisioned by employers responding to this survey. The demand for graduates of formal courses of two years or more is particularly strong, but the supply is also expected to increase substantially in the next few years because of the rapid proliferation of two-year colleges.[1]

Recruitment of technicians and trainees for technician programs was more difficult than a year ago, but not as much as for engineers.

Employers expect an increasing proportion of their technicians to be graduates of technical institutes, and the ratio of technicians to engineers to increase. They also plan to train more technicians in-house.

Technician separations at 9.0% were slightly higher than the rate for engineers, but down substantially from two years ago.

INDUSTRY SUMMARIES

AEROSPACE. The industry was a leader in growth of engineering employment, with a 15.8% increase in 1965 and a predicted increase of 61% between 1965 and 1976. Demand for new bachelor's degree graduates and experienced engineers was particularly high in 1966. Future prospects for advanced degree holders are excellent, but the industry expects the proportion of nongraduate engineers to decrease. There is a strong present and future demand for mechanical, electrical, and aerospace graduates, with a high degree of interchangeability between curricula permissible. The separation rate of 10.2% was above average.

---

[1] Although the enrollments and degrees awarded by ECPD accredited technical institutes have been fairly constant in recent years, a 1966 survey of enrollments conducted by EMC disclosed a great increase in other institutions offering technician curricula.

Technician recruitment is most difficult for experienced personnel and trainees for upgrading programs. Increased training of technicians within the industry is anticipated. The projected rate of increase in technician employment is moderately high, and will produce many openings because of the large numbers already employed.

CHEMICALS. Steady and somewhat above-average growth is anticipated in engineering employment, with a 48% increase from 1965 to 1976. Recruitment of all levels of college graduates was very difficult in 1966, but no trouble was reported with nongraduates. Future prospects are particularly high for master's degree graduates, less so for doctor's. The proportion of bachelor's degree holders is expected to decrease. Chemical and mechanical engineers are most in demand, with relatively little flexibility between curricula acceptable for given openings. The separation rate was below average at 4.4%.

Technician employment is fairly low but shows a high rate of growth. Opportunities for new technical institute graduates are particularly good but there is little evidence of increased in-house training.

The industry gives a general picture of upgrading the qualifications for its technological personnel at all levels.

CONSTRUCTION. Very high growth in 1964-1966 is expected to continue through 1976, with the overall rate of 52% being fourth highest of all activities. Opportunities for new graduates may be less favorable than in other industries because of a relatively small number of openings per 100 employed engineers. Difficulty was experienced in recruiting engineers at all degree levels, and also nongraduates in 1966. The industry envisions an increase in the proportion of advanced degree holders and a decrease in bachelor's and nongraduates, but 38% of current openings are available to nondegree personnel. Demand for civil and electrical engineers is highest, with a substantial requirement for mechanical and others. Flexibility is pronounced only in a willingness to substitute nongraduates for graduate engineers. The separation rate of 11.3% was high, with 8.9% due to resignations, the highest rate for any activity covered by the report.

Technician employment growth is high but possibly erratic from year to year, partly because the absolute numbers of technicians employed appear to be low. Demand for experienced employees and trainees is higher than for technical school graduates, and no major increase in the proportion of graduates is envisioned.

This industry offers more opportunities for nongraduates than most others. Technicians should also benefit from openings in this category.

CONSULTING. This activity is characterized by a large number of fairly small firms.[1] Overall growth will be moderate, with a 24% increase in the 1965-1976 period. The industry reported lower than average recruiting difficulty in 1966. Opinion as to changes in staff composition varies markedly among respondents, with a trend toward master's degrees evident. Hires will be predominantly from the civil engineering curriculum, but with substantial and growing requirements for electrical and mechanical graduates. There is relatively little flexibility between curricula, but a fairly high acceptance of nongraduates. The separation rate of 13.2% was the highest of any activity studied, and the resignation rate of 8.6% was second only to construction.

The technician picture indicates a 1965-1976 growth of 61%, which is quite high. 1966 recruitment was more difficult than in most other industry groups. Although the proportion of technicians is not expected to change much, prospects for new technical school graduates look good, and there should also be an increase in company trainees.

ELECTRONICS AND ELECTRICAL. Growth rates were moderate in 1964-1966, and the increase from 1965 to 1976 is estimated at 40%. Because of the large numbers of engineers already employed, the percentage of new openings is low. Nevertheless, 1966 was a difficult recruiting year for all levels of engineers. Future requirements for master's and doctor's degree holders should increase, but there is little demand for nongraduates in this field. Electrical engineers are naturally most wanted, but so are large numbers of mechanical engineers and a healthy sprinkling of other disciplines. There is a relatively high willingness to accept graduates from different curricula including physical sciences, but not nongraduates. The separation rate, 3.9%. was very low in 1965.

---

[1] The sample consisted mainly of construction-oriented firms, therefore the findings may not be typical of the newer management consultant organizations.

This industry showed the greatest increase in technician employment in 1965 and 1966, and indicates strong growth in the decade ahead. New graduates and experienced technicians were very difficult to hire in 1966. Continued growth through both hiring and upgrading is envisioned.

MACHINERY. Growth in employment was slow and promises to remain so through 1976, but recruiting was about as difficult as for the average respondent in 1966. The trend toward advanced degrees is not as strong as in most other activities. New hires are mainly from the mechanical engineering curriculum, followed by electrical and industrial. There is a high degree of flexibility between curricula, but little need for graduates of non-engineering curricula or for nongraduates. Separation rates were low.

Future growth in technician employment is expected to be high, with good opportunities for technical school graduates as well as trainees. New graduates, however, were less difficult to recruit in 1966 than were trainees and experienced personnel.

METALS. This industry showed less than average employment growth from 1964 to 1966. The long-range increase should be better, but percentages may not be accurate in view of the small absolute numbers reported. Opportunities for new graduates appear to be quite favorable. Recruiting in 1966 was generally less difficult than reported by other activities. Future demands for master's and doctor's degrees should be strong. Curricula most in demand are mechanical and metallurgical, with healthy numbers of most others as well. There appears to be a great deal of flexibility in this industry, with better than average opportunity for the nongraduate or non-engineer to step into an engineering job. Separations were abnormally low at 1.4% in 1965.

Technician employment growth was slow, and a decrease is predicted for the long range, but this is contradicted by the opinion that the ratio of technicians to engineers will increase. Plans for internal training are small, so that technical school graduates will be the principal source of supply. 1966 recruitment of technicians was difficult except for trainees.

In view of the conflicting indications, the outlook for the metals industry cannot be predicted with confidence, but the favorable signs appear to be stronger than the unfavorable.

PETROLEUM. The growth rate for engineers is low but relatively stable. Bachelor's and master's degree graduates were particularly hard to recruit in 1966 and the future outlook for master's is very good. All kinds of engineers are needed, especially chemical, mechanical, petroleum, and electrical. Requirements for a specific curriculum are strict, and there is little opportunity for nongraduates. The separation rate of 6.8% was about average for all respondents.

Growth in technician employment is also expected to be moderate, but the technical institute graduate appears to enjoy relatively good opportunities, as company training programs are not a large factor. This industry reported the least difficulty in technician recruitment of any activity in the 1966 survey, especially with respect to experienced technicians.

RESEARCH AND DEVELOPMENT. Current growth rates are moderate but long-term trends indicate a definite slowdown with only a 10% increase in engineering employment from 1965 to 1976. Recruiting difficulty was less than most other activities in 1966, with master's degree graduates hardest to hire. As would be expected, the proportion of advanced degree holders is expected to increase while that for bachelor's and nondegree personnel will decrease. Electrical engineers are most needed by the responding companies, followed by mechanical, but a high degree of interchangeability is acceptable for specific openings. The separation rate of 7.2% for 1965 was above average for all employers.

Technicians can also look forward to only moderate growth in research and development employment. Employers do not expect the proportion of technicians to change in the next decade, nor is much in-house training contemplated. Technical school graduates should have relatively favorable job opportunities. This is also borne out by the reported difficulty in recruiting such graduates in 1966, compared to the lesser problems with regard to experienced technicians and trainees.

TRANSPORTATION. Little or no growth is envisioned in engineering employment in this industry for the next decade, yet the respondents reported considerable difficulty in 1966 recruiting activities. Opportunities for advanced degree engineers are relatively poor, but the nongraduate appears to have even less chance. Mechanical, electrical, and aerospace graduates are most in demand, with a good deal of flexibility among these curricula. Graduates of non-engineering curricula are acceptable in 32% of the openings. Separations in 1965 were low at 4.5%.

Technicians appear to enjoy an unusually high employment growth rate in the transportation industry, but it is anticipated that more will be trained within the companies than hired from technical institutes. Hiring of technicians was generally difficult in 1966.

The long-range picture for transportation may be strongly influenced by new developments in rapid transit and by increased government emphasis under the new Department of Transportation. The future outlook may thus be more optimistic than this survey would indicate. Trends in the next few years should be watched closely for signs of major changes.

UTILITIES. Employment of engineers will remain at or below existing levels. Despite, or perhaps because of, the lack of growth, the industry found recruiting quite difficult in 1966. Future trends are less definite than in other industry groups, with an expected increase in master's degrees most pronounced. New hires were heavily from the electrical curriculum, with mechanical engineers next in demand. Flexibility was very low, and the demand for nongraduates almost nonexistent. Separations at 5.2% were below average for 1965, but retirements were the highest for any industry - 2.0%.

Large numbers of technicians are employed in the utilities, and some growth is indicated, with both company training programs and technical institutes expected to supply the need. Recruiting was fairly difficult in 1966.

Growth expectations in this industry appear to favor the technician over the engineer. Engineering employment will apparently consist of replacing losses due to death and retirement rather than filling newly created jobs.

FEDERAL GOVERNMENT. Employment will remain almost static, if replies to this survey prove to be characteristic of federal activities. The 1965-1976 growth of 6% is far lower than the rate prevailing in recent years. Recruiting of new college graduate engineers was very difficult this year at the bachelor's and master's level, less so for doctor's degrees. No trouble was encountered in hiring nongraduates, and decreasing opportunity is in store for these. An increase in the proportion of master's degrees is predicted, but for doctor's a smaller increase is indicated. All kinds of specialists are required, with electrical, civil, and mechanical most in demand. There is relatively little flexibility between curricula, although physical scientists can qualify for 21% of the positions. Separations in 1965 were at 7.0%, which is slightly higher than the industrial average. The retirement rate of 2.3% is the highest of any group recorded in the survey.

Technician employment growth in the federal government is also very low, and the ratio of technicians to engineers is not expected to increase much. Upgrading of employees through training programs is expected to provide most of the new technicians. No difficulty was noted in hiring experienced technicians in 1966. Trainees were harder to find than new technical school graduates.

STATE GOVERNMENT. Growth should be higher than in the federal activities but still less than in most industries. Despite the small increase in 1965 and 1966, all levels of engineers were difficult to recruit. More engineers with master's degrees will be needed in the future, but 50% of the state agencies also expect to increase the proportion of nongraduates. Civil engineers dominate the requirements, but almost one-third of the positions could be filled by nongraduates. Separations for 1965 were 7.5%, mostly resulting from resignations.

Technician employment will grow moderately, but the widespread use of nongraduates in engineering positions, as noted earlier, will mean more opportunities for advancement. New hires from technical school graduates are expected to increase, but training programs will also be widely used. The main difficulty in 1966 recruiting seems to have been for experienced technicians, with new graduates and trainees less difficult to hire.

LOCAL GOVERNMENT. Growth in the last two years exceeded the other governmental sectors, but a decline is predicted by 1976. Recruiting was fairly difficult in 1966 except that experienced graduate engineers were not so hard to hire. Little increase in the proportion of advanced degrees is anticipated, with most respondents feeling that the status quo will prevail. Nondegree employees, however, are expected to decrease. Civil engineers are by far the most in demand, but in future years the need for other specialties will grow. Requirements for specific curricula are the most rigid of any group surveyed. The separation rate in 1965 was 7.1%.

The technician growth rate will be higher than in the other government groups but well below the industry average. Technical school graduates should do well because training programs will produce fewer new technicians than in the federal and state organizations. Only moderate recruiting difficulty was encountered this year.

EDUCATION. Colleges and schools reported strong growth in the last two years, and predict a 66% increase from 1965-1976, the highest of any activity in this survey.[1] Only moderate difficulty was encountered in 1966 hires. The greatest future increase will be in the proportion with doctor's degrees; even the master's category is not expected to grow. Graduates of all curricula are wanted, more or less in proportion to the numbers of students currently enrolled in each. Employment opportunities in the education field include research activities as well as teaching. Demand is quite specific in terms of particular curricula, and opportunities for nongraduates are negligible. The 1965 separation rate of 8.4% was high, as was the resignation rate of 5.9%.

Technician employment grew moderately in 1964-1966, but a strong increase is envisioned by 1976. The actual numbers of technicians employed are not very great, however. Growth is expected in both technical institute graduate hires and in training programs within organizations. Recruiting in 1966 was not particularly difficult except in the case of experienced technicians.

The overall picture in education is one of continuing strong growth and high demand, with enough candidates actively seeking jobs in this field to keep recruiting from becoming a major problem. The increased numbers of engineers earning doctorates will find themselves in relatively greater demand for educational positions than for jobs in industry, and this will coincide with the individual preferences of many.

---

[1] Much of this increase can be attributed to the anticipated lengthening of the average engineering curriculum and longer duration of schooling as more engineers take advanced degrees. Because of these developments, more teachers will be required to produce the same number of new engineers.

4

A Survey Parallel

The parallel on the next page compares the current survey with that conducted two years ago. Please note that the respondents are not identical and that changes in methodology may have made some categories not exactly comparable from year to year. Adjustments have been made where necessary to compare identical time periods in the two surveys.

1964 Report (Data for 1963)		Item	1966 Report (Data for 1965)	
543		Number of respondents	490	
365,477		Total number of engineers, physical scientists, and technicians covered	278,258	
		ENGINEERS		
26.2%		Projected ten-year growth in total engineering employment	30% *	
Paper Products	64.6%	Categories with highest projected growth rates in total engineering employment	Education	60%
Instrument Mfg.	60.9%		Aerospace	55%
Food Products	49.2%		Construction	47%
Research & Development	37.6%		Metals	47%
65.2%		Projected ten-year growth in new graduate demand	92% 69,000 per year *	
39,000 per year (Bachelor's degree)		Ten-year projection of supply of new engineering graduates	41,100 per year (all degree levels)	
9.6%		Separation rate for all categories	6.5%	
Construction	14.9%	Categories with highest separation rates	Consulting	13.2%
Aerospace	13.8%		Construction	11.3%
Elect. & Electronics	12.1%		Aerospace	10.2%
6.0%		Resignations as a percent of total engineering employment	4.3%	
		TECHNICIANS		
29.1%		Projected ten-year growth in total technician employment	33%	
Food Products	86.8%	Categories with highest projected growth rate in total technician employment	Transportation	133%
Stone,Clay & Glass	69.9%		Education	104%
Instrument Mfg.	68.0%		Machinery Mfg.	96%
12.7%		Separation rate for all categories	9.0%	
Construction	28.9%	Categories with highest separation rates	Consulting	31.8%
Aerospace	25.6%		Machinery Mfg.	17.7%
Instrument Mfg.	25.2%		Aerospace	11.4%
7.4%		Resignations as a percent of total technician employment	5.9%	

*Adjusted figure. See Appendix page 73.

5 The Demand for Engineers

A. EMPLOYMENT

WHAT HAS BEEN THE GROWTH OF TOTAL ENGINEERING EMPLOYMENT?

Overall, engineering employment grew by a healthy 7.2% from 1964 to 1965. The anticipated growth from 1965 to 1966 was estimated at 9.0% at the time the questionnaires were filled out, in the Spring of 1966. It is probable that this figure was exceeded, as all other indications showed that 1966 was a year of almost unprecedented demand. The U.S. Department of Labor's Bureau of Employment Security reported that openings listed by public employment offices exceeded the number of applicants for the first time since the current series of statistics was started eight years ago. There were 15% fewer engineers seeking jobs than positions listed, whereas in 1965 there had been more than two applicants registered for every opening. It is therefore apparent that 1966 is an even better year than 1965, as far as engineering employment is concerned. Figures for industry and government, adjusted to simulate the total employment patterns, are:

	Increase in Total Engineering Employment	
	1964-1965	1965-1966
All Industry	8.0%	9.9%
All Government	3.1%	3.0%

For the separate activities, the largest growth in 1965 was registered by the aerospace industry with 15.8%, followed by construction with 14.0%, and consulting with 11.2%. Little growth was indicated in the utilities, petroleum, and metals industries, and local government. The 2.3% growth reported by federal government activities is in strong contrast with the 12% reported in 1963. Other activities are shown in Table 1 on the next page.

TABLE 1

Growth in Engineering Employment, 1964-1966

ACTIVITY	Returns	1964 Actual	1965 Actual	1965 % Increase	1966 Estimated	1966 % Increase
Aerospace	15	33,162	37,907	15.8	41,315	9.0
Chemical	16	12,244	12,759	4.2	13,641	6.9
Construction	27	2,101	2,383	14.0	2,651	11.2
Consulting	66	3,088	3,436	11.2	4,592	4.5
Electronics & electrical	35	44,443	47,723	7.4	51,082	7.1
Machinery	33	4,846	5,330	10.0	5,975	12.1
Metals	18	5,857	5,954	1.7	6,159	3.4
Misc. Mfg.	19	2,779	2,911	4.8	3,094	6.3
Petroleum	14	7,614	7,738	1.6	7,915	2.3
Research & Development	14	5,771	6,078	5.3	6,541	7.6
Transportation Services	12	683	707	3.5	746	5.5
Utilities	55	10,279	10,291	0.1	10,467	1.7
Federal Government	20	11,231	11,494	2.3	11,750	2.2
State Government	13	7,666	8,040	4.9	8,278	3.0
Local Government	30	2,067	2,085	0.9	2,182	4.6
Education	103	5,694	6,151	8.0	6,792	10.4

Current rates of total engineering employment growth are compared with the rates developed in previous surveys in Table 2 below:

TABLE 2

ENGINEERING: GROWTH IN TOTAL EMPLOYMENT, 1951 THRU 1965

YEAR	RETURNS	ENGINEERS EMPLOYED BY SURVEY RESPONDENTS		
		JAN. 1	DEC. 31	GROWTH
1951	380	138,113	153,007	10.8%
1952	376	116,653	124,578	6.8
1953	376	126,086	131,778	5.3
1954	377	132,000	137,560	4.2
1956	414	140,466	154,608	10.1
1957	471	175,583	187,140	6.6
1958	480	207,029	217,857	5.2
1959	509	199,229	211,052	5.9
1960	517	190,139	197,251	3.7
1961	517	196,385	203,113	3.4
1962	543	233,994	244,530	4.5
1963	543	244,530	252,312	3.2
1964	490	154,970	159,525	2.9*
1965	490	159,525	170,987	8.2*

*Unadjusted figures. Adjusted values are 6.9% and 7.2% respectively.

In view of the variations between surveys, these percentages are not exactly comparable from year to year, but indicate in a rough way how engineering employment has expanded.

B. RECRUITMENT

HOW DIFFICULT WAS ENGINEERING RECRUITMENT THIS YEAR?

By all accounts, recruitment of engineers was much more difficult in 1966 than a year ago. Only a few scattered activities reported that they were experiencing less difficulty in obtaining engineers of any educational level. Overall, new graduates with bachelor's degrees were hardest to recruit, followed by experienced graduate engineers, new master's degree graduates, non-graduates, and new doctor's degree graduates, respectively. The percentage of all respondents, weighted in accordance with the number of hires, who experienced more difficulty in recruiting, varied as follows:

New graduates, bachelor's degree	93%
Experienced graduate engineers	88%
New graduates, master's degree	73%
Non-graduates	61%
New graduates, doctor's degree	52%

There were some significant variations in the recruiting picture among activities. The least difficult fields for hiring bachelor's degree holders were research and development and education. Consulting, metals, utilities, and local government also reported less than average difficulty in recruiting at this level.

The greatest difficulty in finding new master's degree graduates was reported by the construction. petroleum, electronics, transportation and chemical industries, and by the federal government. By far the weakest area was state government, but education also indicated less than average difficulty in recruitment.

The picture with regard to doctor's degree engineers was quite similar to that for the master's, with construction, electronics, and transportation reporting the most difficulty. Surprisingly enough, research and development was one of the weakest areas--apparently a great many graduates are looking for work in this field, so that employers are not finding recruiting a problem. Other relatively soft spots appear to exist in the metals industry, state government, and to some extent in aerospace and consulting.

Experienced graduates were hardest to come by in aerospace and electronics, with least difficulty in education and local government. Research and development also reported relatively less difficulty in recruiting this category of engineers. All other activities reported a quite high degree of difficulty.

Finally, nongraduates seemed to be hardest to hire in construction and electronics, and easiest to recruit in the federal government and the chemical industry. Research and development, metals, and utilities also tended to find recruiting easier than most other industries.

The figures for all activities are shown in Table 3 on the next page.

It should be noted that this matter of difficulty in recruiting is strictly a relative thing, in that respondents were asked only to compare this year's experience with last year's. As easing in the relative difficulty of recruiting could still take place in the presence of a very strong actual demand. The matter of supply is also an important factor, because the popularity of certain fields could lure more new graduates to apply for positions in a particular industry. To the recruiter, this would make hiring look easier. Despite these ambiguous factors, the recruitment statistics, taken in combination with other information, offer additional insight to the nature and degree of engineering demand.

C. GROWTH

HOW DO EMPLOYERS ESTIMATE THEIR ENGINEERING GROWTH FOR THE NEXT DECADE?

For the 11 years from 1965 to 1976, it is estimated that the total national employment of engineers will grow by 33%, or an average of 3% per year. (This figure was obtained by adjusting the returns for each activity as described in the Appendix, page 73.) The highest growth rates are projected for the aerospace and construction industries, and for education. Declines are forecast by utilities and local government. Other activities are shown in Chart A on page 33.

There is an interesting phenomenon observable in practically all of the projections, in that the high actual and estimated growth rates for 1964-1966 are followed by much more conservative projections for 1967, 1971, and 1976. The future predictions are based on an average between the high and low estimates made by respondents (see Part 5 of the questionnaire, page 91). Chart B on page 34 shows this picture for all industry and for several individual activities. It is interesting to speculate whether the 1967 and future estimates are low because of a general tendency toward conservatism in projecting estimates into the future, because of a belief that the current rate of employment increase simply cannot continue, or because of doubts about the general economy.

TABLE 3

1966 Engineering Recruitment Picture Compared To 1965

How Respondents Reported Degree of Difficulty in Recruiting Engineers

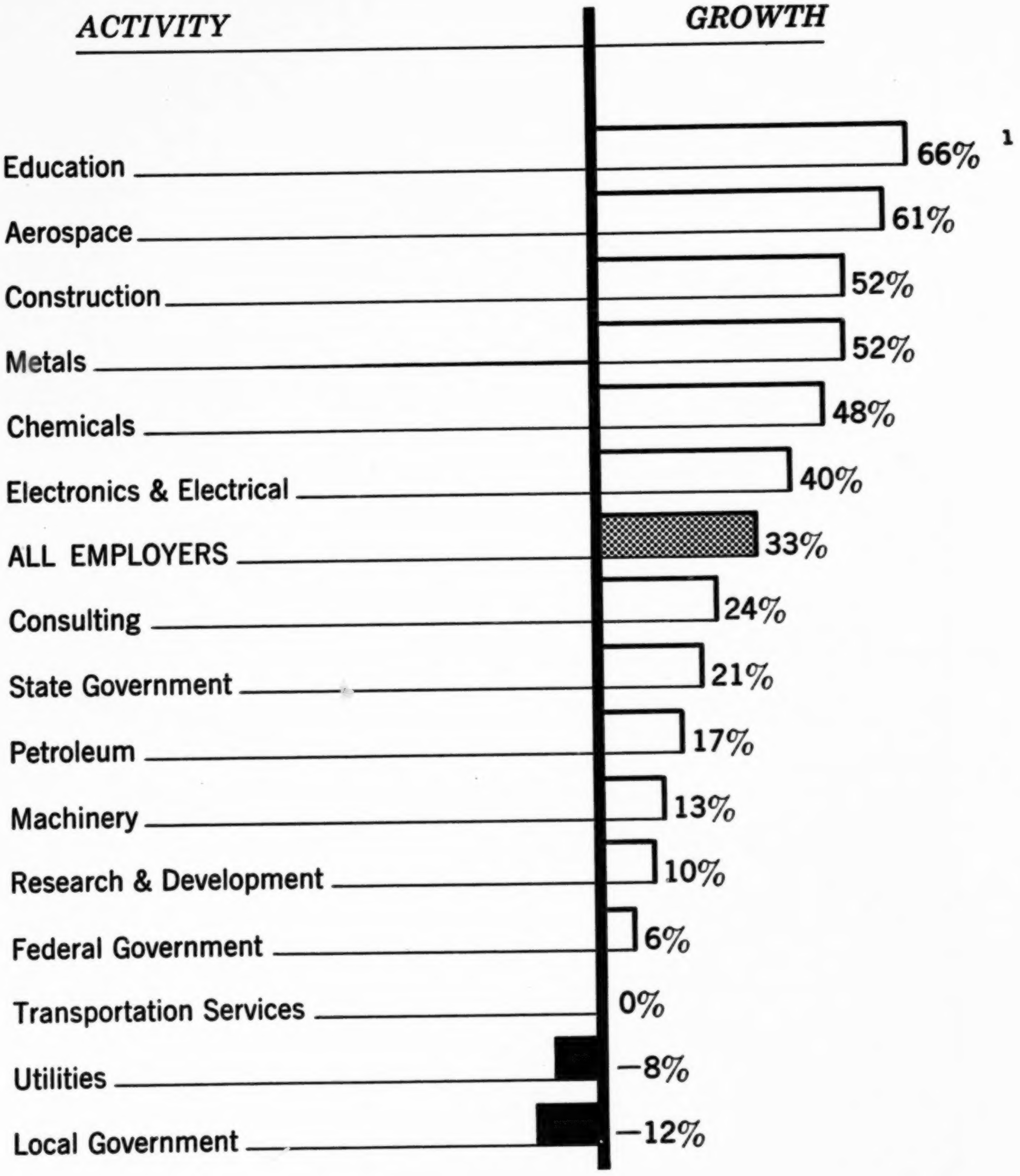
ACTIVITY (1)	Number of Respondents	Number of Hires	New Graduates Bachelor's			New Graduates Master's			New Graduates Doctor's			Experienced Graduate Engineers			Nongraduates		
			More Difficult	Same	Less Difficult	More Difficult	Same	Less Difficult	More Difficult	Same	Less Difficult	More Difficult	Same	Less Difficult	More Difficult	Same	Less Difficult
All Respondents	470	22,136	93%	5%	2%	73%	26%	1%	52%	46%	2%	88%	11%	1%	61%	37%	2%
Aerospace	15	8,619	100	0	0	63	37	0	22	78	0	100	0	0	59	41	0
Chemical	14	1,070	99	1	0	86	14	0	77	23	0	79	20	1	1	96	3
Construction	21	518	99	1	0	99	1	0	99	1	0	86	14	0	97	3	0
Consulting	62	697	67	33	0	66	21	13	45	55	0	81	19	0	47	42	11
Electronics & Electrical	35	5,149	96	4	0	95	5	0	96	4	0	98	2	0	88	12	0
Machinery	31	705	94	6	0	71	29	0	62	38	0	86	14	0	78	22	0
Metals	18	173	67	33	0	60	40	0	5	95	0	53	47	0	24	76	0
Misc. Mfg.	19	315	99	1	0	91	9	0	93	7	0	86	14	0	70	30	0
Petroleum	14	650	99	1	0	98	2	0	68	32	0	66	33	1	62	38	0
Research & Development	14	746	46	7	47	69	31	0	10	43	47	50	50	0	23	77	0
Transportation Services	9	48	85	15	0	91	9	0	91	9	0	85	15	0	68	32	0
Utilities	55	537	76	24	0	81	18	1	81	19	0	60	40	0	43	57	0
Federal Government	19	1,017	100	0	0	95	5	0	68	32	0	70	30	0	0	97	3
State Government	13	975	91	4	5	9	91	0	16	84	0	90	5	5	79	18	3
Local Government	29	131	79	20	1	65	35	0	54	46	0	28	71	1	70	29	1
Education	102	786	48	51	1	46	51	3	51	40	9	28	69	3	39	34	27

Note: Totals may not add to 100% due to rounding.

(1) All replies weighted in proportion to numbers of engineers hired in 1965.

CHART A

PROJECTED GROWTH OF ENGINEERING EMPLOYMENT, 1965--1976



---

[1] See footnote on page 23.

CHART B

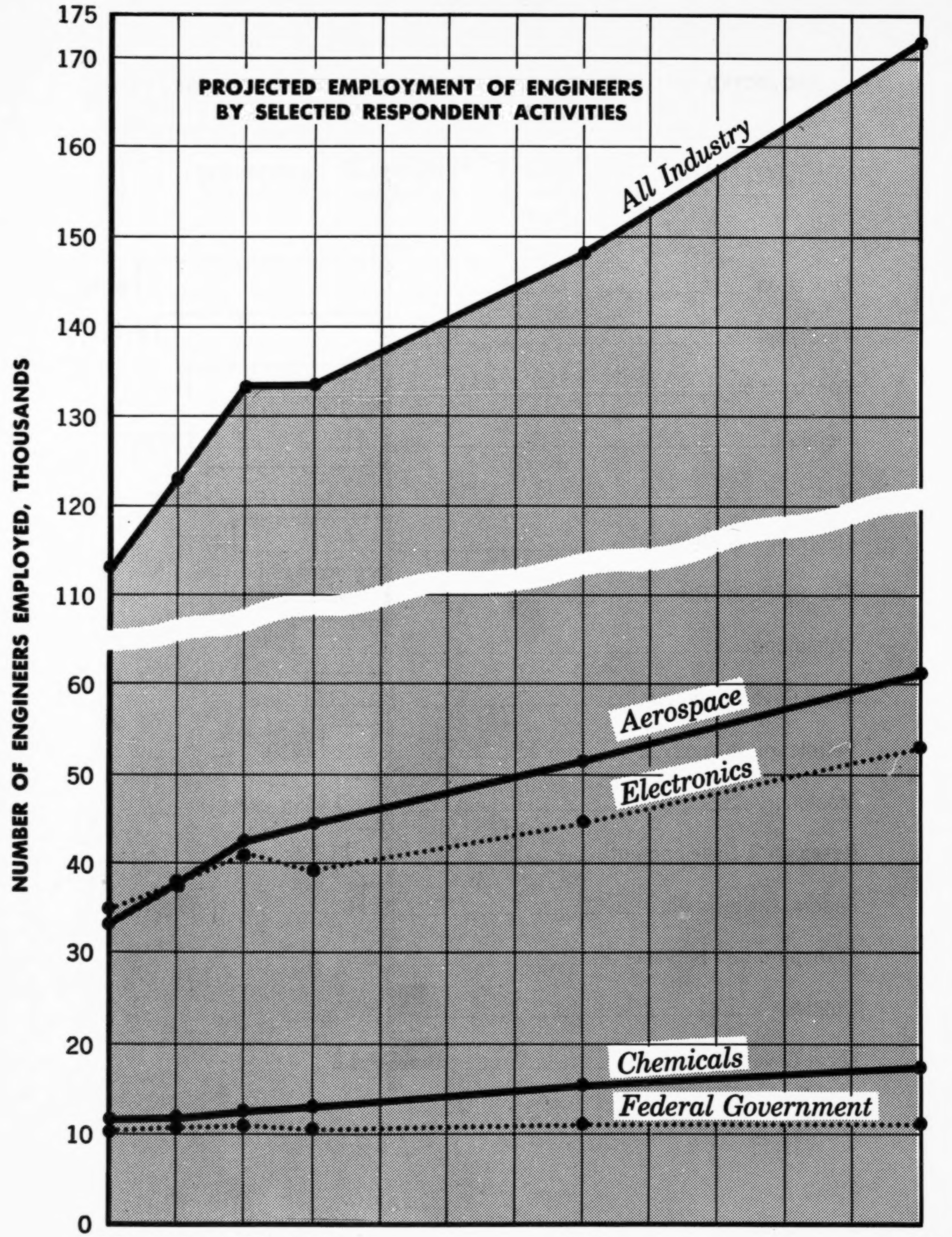

PROJECTED EMPLOYMENT OF ENGINEERS
BY SELECTED RESPONDENT ACTIVITIES
NUMBER OF ENGINEERS EMPLOYED, THOUSANDS
175
170
160
150
140
130
120
110
60
50
40
30
20
10
0
1964
1965
1966
1967
1971
1976
All Industry
Aerospace
Electronics
Chemicals
Federal Government

Table 4 on page 36 shows the projected increases for all activities. It should be noted that different patterns exist for different industries. In 1967, for instance, only construction shows a greater increase than in 1964-1966. Consulting, machinery, research and development, and transportation show actual decreases at various points. Considering the high popular regard for research and development as a motivating factor in the national growth, the projected performance in this activity appears to be quite lackluster. Also surprising is the small predicted growth in all three areas of government, with declines indicated in some years. If such reductions actually happen, they will be contrary to all recent experience and a reversal of the longstanding trend toward growth in governmental activities.

The outlook in the utilities industry is consistently pessimistic, and machinery and petroleum show low overall growth rates. The chemicals industry anticipates a steady growth at an above-average rate. Most other activities show fairly wide variations in the predicted growth rate from year to year.

It would be incorrect to attribute too much significance to these figures except as indicating general trends. A detailed analysis (not published) was made of the growth rates from year to year from 1964 to 1976, based on responses to questions on 1964-1966 employment (Table 1) and on the smaller number of replies to questions on future trends (partially summarized in Table 4). There is a considerable degree of variability in growth rates based on year to year comparisons, but the general trends are clear, as brought out by the overall growth indicated in Chart A and the last column of Table 4.

The overall thrust of these figures is to indicate a continued healthy growth rate for total engineering employment over the next decade. Predictions more than a year or two into the future are understandably tempered with caution. Sharp changes in the growth rate which are forecast for certain industries at certain years should be weighted against other factors and trends before being accepted at face value, as it is more likely that they represent conservatism in the face of future unknowns than any planned cutback in production or employment. Finally, judgment should be reserved until other factors, such as the supply of new engineers, are considered, as the numbers of new engineering graduates may be inadequate to support even a 3% annual increase plus the replacement of normal attrition.

TABLE 4

Long Range Growth in Engineering Employment to 1976, by Activity

ACTIVITY	Returns	1965 Actual	1967 Projected	1971 Projected	1976 Projected	Total % Increase 1965-1976
Aerospace	14	37,715	44,359	51,554	60,680	61
Chemical	11	11,771	12,963	15,037	17,451	48
Construction	19	2,335	2,950	3,485	3,556	52
Consulting	52	3,022	3,288	3,179	3,759	24
Electronics-Electrical	28	37,678	39,333	44,476	52,773	40
Machinery	29	4,913	3,814	4,629	5,554	13
Metals	12	594	628	761	912	52
Misc. Mfg.	13	2,250	2,509	2,910	3,501	56
Petroleum	12	7,614	7,810	8,337	8,886	17
Research & Development	11	5,578	5,958	5,365	6,122	10
Transportation Services	9	550	602	448	548	(0)
Utilities	44	8,647	8,544	7,695	7,980	(-8)
Federal Government	17	10,386	10,170	10,521	10,983	6
State Government	10	7,354	7,588	8,156	8,879	21
Local Government	22	1,460	1,498	1,273	1,288	(-12)
Education	87	5,310	6,476	7,610	8,831	66[1]

Note: Fewer respondents answered the questions on future trends than those pertaining to employment in 1964-1966. Therefore the 1965 figures in this table do not correspond exactly to those in Table 1.

---

[1] See footnote on page 23.

D. NEW HIRES

WHAT IS THE CURRENT PICTURE WITH REGARD TO NEW HIRES?

Additions to engineering staffs in 1964-1966 were as follows:

	1964	1965	1966 (est.)
New graduates	43.1%	38.1%	43.2%
Experienced graduate engineers	45.5%	46.8%	45.0%
Nongraduates	11.4%	15.1%	11.8%
All Hires	100.0%	100.0%	100.0%

It is of interest to note that the 1966 estimates indicated a desire to maintain the proportions which had existed in 1964, whereas the 1965 actual figures showed a trend toward hiring more experienced graduates and nongraduates. In view of other indications disclosed by this survey, it is safe to say that the decrease in the percentage of new graduate hires is a reflection of an inadequate supply of graduates, rather than a preference for other categories. There is also reason to believe that an even tighter situation existed with the supply of June 1966 graduates, so that the actual results in 1966 will probably show a continuation, rather than a reversal, of the 1964-1965 trend.

Among new graduates hired, degrees were distributed as follows:

	1964	1965	1966 (est.)
Bachelor's	78.4%	77.2%	76.3%
Master's	15.1%	17.0%	16.9%
Doctor's	6.5%	5.8%	6.8%
All graduates	100.0%	100.0%	100.0%

These figures confirm the trend toward more advanced degrees, but the change still appears to be quite gradual. In part this is due to the relatively small numbers of master's and doctor's degree engineers available in comparison with the overall supply, such that a drastic increase in hires of engineers with advanced degrees would be practically impossible. Responses to other questions in this survey, however, indicate that employers actually prefer bachelor's degree engineers for a great majority of their new openings. One employment manager of a large industrial organization, when asked to comment on this question, replied that his company would prefer to hire new graduates with bachelor's degrees, but recognized that it had to recruit engineers at the master's level in order to attract the brightest candidates. He felt that employers realized they would have to hire increasing proportions of men with advanced degrees, but that they did not necessarily prefer it this way. Responses to this survey tend to bear out this appraisal, showing a de facto increase in advanced degree hires but a higher demand for bachelor's degree graduates.

Complete figures on new hires for 1964, 1965, and 1966 are included in Appendix Tables I, II, and III.

E. NEW GRADUATES

HOW DO PROSPECTS FOR NEW BACHELOR'S DEGREE GRADUATES LOOK FOR THE FUTURE?

In addition to estimating total employment, respondents were asked to state their anticipated hires of new graduates at the bachelor's level. The detailed responses are given in Appendix Table IV.

By adjusting the replies for each activity in accordance with their proportion of the total national employment of engineers, (see Appendix, page 73 for methodology), it is estimated that about 830,000 new engineering bachelor's are wanted for the 12 years from 1965 to 1976. This averages out to 69,000 graduates per year, a figure which is reasonably in line with other predictions such as National Science Foundation's 1963 projection of 71,000 per year[1] and Engineering Manpower Commission's 1964 estimate of 45,000.[2] The principal significance of this figure is that it shows that employers, considering their own individual desires without reference to overall limitations and restrictions, think they will need almost twice as many engineers as are likely to become available in the next decade. A potential demand of this magnitude is a strong indication of excellent opportunities for the engineering graduates of future years. It is also so much greater than supply that minor fluctuations in all industries, or even major dislocations in a few of them, are unlikely to have much impact on the overall picture. In the words of Harold A. Foecke, Dean of Engineering at Gonzaga University:[3]

---

[1] National Science Foundation, *Scientists, Engineers, and Technicians in the 1960's — Requirements and Supply*. NSF 63-34. 1964.

[2] Engineering Manpower Commission of Engineers Joint Council, *Demand for Engineers, Physical Scientists, and Technicians — 1964*. July, 1964.

[3] Foecke, Harold A. *The Engineering Manpower Situation — Present and Future*. New York: Engineering Manpower Commission of Engineers Joint Council. February, 1965.

> "...there are at work in our economy (or, perhaps more accurately, in our society) abiding forces which tend to require increasingly large proportions of our society to be directly engaged in engineering and scientific endeavors. If this be so, quite apart from the short-term fluctuations caused by monthly variations in the temperature of the cold war, the long-range outlook indicates a growing need for engineers, with numbers increasing more rapidly than the population as a whole."

An interesting comparison can be made by relating new graduates hires to the total number of engineers employed by each activity or industry group. Table 5, which follows, gives a rough measure of the annual opportunity within each industry in terms of new openings per 100 existing engineers on the payroll, based on actual figures for 1965 and estimates for 1976. The relative numbers of openings for new graduates appear to be particularly high in some activities which might be less attractive when viewed in terms of total growth of engineering employment or some other criterion. Thus such fields as metals, machinery, and local government seem to offer especially good opportunities for new graduates, while the highly-regarded electronics industry in 1965 actually had the fewest openings per hundred engineers employed. The figures for all industries indicate continuing growth in demand throughout the decade, as far as new graduates are concerned.

In explanation of these figures, it should be noted that they summarize the combined opportunities for new graduates which result from general expansion of the engineering force, the replacement of engineers lost by normal attrition, and the replacement of non-graduates with graduate engineers. Even in industries where the total employment of engineers is unlikely to grow much, these factors are operating to assure new graduates of generally favorable opportunities.

The favorable outlook for new graduates is perhaps best illustrated by comparing the number of new graduate hires anticipated by respondents with their estimates of total growth of engineering employment for the same period. In this case the unadjusted replies for the period 1964-1976 are used, since the ratios obtained would not change if adjusted figures were used.

For all industrial respondents combined, the total employment growth was 59,105 while the number of new graduate

TABLE 5

New Graduate Hires Per 100 Employed Engineers

ACTIVITY	1965	1976
Aerospace	3.8	5.1
Chemical	4.5	8.6
Construction	2.6	3.4
Consulting	4.5	6.9
Electronics-Electrical	1.7	2.2
Machinery	6.6	11.2
Metals	7.9	16.0
Misc. Mfg.	6.2	10.7
Petroleum	3.7	6.6
Research & Development	3.7	4.7
Transportation Services	3.6	6.6
Utilities	3.8	4.8
Federal Government	4.6	6.7
State Government	4.2	6.7
Local Government	5.8	10.9
Education	5.1	8.2

hires was 79,407 for the same 12-year period. This indicates that industry would like to hire 34% more new graduates than would be needed to meet the needs of employment growth. Comparable figures for government and educational respondents are 450% and 67% respectively.

The additional hires would obviously be used to replace experienced personnel leaving the work force, or to upgrade staffs. Since it is probable that enough new graduates will not be available to satisfy these expectations, the result will be a heightening of competition for those who are available, and a greater degree of choice between job opportunities for the new graduate.

F. CHANGES IN COMPOSITION

HOW WILL THE COMPOSITION OF ENGINEERING STAFFS CHANGE IN THE FUTURE?

Respondents as a whole strongly believe that the proportion of master's and doctor's degree holders will increase in the next decade, while that of bachelor's and non-degree holders will decrease. There are, however, widespread differences in opinion between groups of employers.

The strongest trend appears to be toward an increase in the number of master's degrees, but there are strong minorities in consulting, machinery, transportation services, utilities, state and local government, who disagree. In all these activities the feeling seems to be that the decrease in bachelor's degrees will be relatively less. In education, however, the opinion that master's degrees will not increase is coupled with an overwhelming support for the doctorate.

Belief in an increase in doctor's degrees is particularly high in education, research and development, aerospace, and metals. It is weakest in transportation, local government, and chemicals.

Practically all activities predict declining opportunities for the non-graduate engineer. While the chemical and petroleum industries think the proportion will stay the same, only state governments actually foresee an increase.

Compared to the 1964 survey, this year's results strongly confirm the trend toward higher degrees which the earlier survey had indicated in a more tentative way. The detailed replies are shown in Table 6 on page 43. The percentages cited in the Table were developed by weighting responses by the number of engineers employed.

G. SPECIFIC CURRICULA

WHAT IS THE DEMAND FOR GRADUATES OF SPECIFIC ENGINEERING CURRICULA?

This year for the first time respondents were asked to indicate the percentage of new hires from the most common engineering curricula, both in 1966 and 1976. The results were quite interesting, and are tabulated in full in Appendix Tables V and VI.

One significant finding is that each industry, while it may have a favorite kind of engineer, has substantial requirements for graduates of other curricula. These are summarized in Table 7 on page 44 for 1966 and ten years later. The general trend, as envisioned by most respondents, is toward further broadening the variety of skills required within an industry. However, the degree to which change can be foreseen is surprisingly small. For instance, the proportion of nuclear engineers in the utilities industry increases only from 2% to 3%. A few changes may have some significance. The consulting group shows a shift away from civil engineers in favor of electrical and mechanical. In the metals industry, a drop in metallurgical engineers is balanced by an increase in aerospace, possibly representing long-range changes in product planned by individual companies. The petroleum industry shows fewer electrical and more chemical engineers for 1976. Transportation indicates a big increase in civil engineers, and smaller increases in the metallurgical and nuclear categories, which are balanced by substantial reductions in mechanical, chemical, industrial, and aerospace. Of all industry groups, this one seems to anticipate the greatest technological changes, as evidenced in the engineering specialties expected to be hired.

In the government areas, the federal group forecasts a shift from mechanical to civil, while the local sector sees a reduction in civil engineers in favor of electrical and mechanical. The state level remains overwhelmingly a province for the civil engineers.

The only shift apparent in education is toward a more even distribution of all specialties, which is consistent with the trend toward viewing engineering as a more unified field.

TABLE 6

FUTURE TRENDS

How Respondents Believe the Proportion of Engineers at Various Degree Levels Will Change Over the Next Decade

ACTIVITY (1)	Bachelors			Masters			Doctors			No Degree		
	Increase	Same	Decrease	Increase	Same	Decrease	Increase	Same	Decrease	Increase	Same	Decrease
All Respondents	15%	25%	60%	86%	12%	2%	67 %	32%	2 %	5%	20%	75%
All Industry	15	25	60	91	9	0	70	29	1	2	21	77
Aerospace	20	45	35	96	4	0	95	5	0	*	*	99
Chemical	*	*	98	99	*	0	15	85	0	0	79	21
Construction	23	4	73	98	2	*	78	22	*	4	1	95
Consulting	14	35	51	76	24	0	27	71	2	7	32	61
Electronics-Electrical	2	19	79	95	5	0	80	20	0	1	6	93
Machinery	27	22	51	67	33	*	29	52	19	9	26	65
Metals	8	1	91	93	7	0	91	7	2	2	5	93
Misc. Mfg.	20	14	66	82	18	0	73	26	1	2	9	89
Petroleum	28	0	72	99	*	0	49	51	0	0	80	20
Research & Development	*	4	96	97	3	0	97	3	0	0	10	90
Transportation Services	29	32	39	59	41	0	0	93	7	0	1	99
Utilities	30	36	34	69	31	0	28	66	6	9	27	64
All Government	17	28	55	79	17	4	37	59	4	23	12	65
Federal Government	3	39	58	85	12	3	43	57	0	3	14	83
State Government	36	10	54	77	18	5	33	54	13	50	9	41
Local Government	16	54	30	48	48	4	0	87	13	20	15	65
Education	1	13	86	18	47	35	99	*	0	5	34	61

Note: Total may not add to 100% due to rounding
(1) All replies weighted in proportion to numbers of engineers employed.
* Less than 1%

TABLE 7

New Hires From Specific Curricula
Current and Future

Percentages for 1966/1976

ACTIVITY (1)	Electrical	Mechanical	Civil	Chemical	Industrial	Special	All Other
All Respondents	31/33%	26/25%	14/12	7/9%	4/4%		18/17%
Aerospace	26/24	28/28	9/8	2/2	3/4	Aerospace 25/24	7/10
Chemical	5/9	29/30	5/5	47/42	6/6		8/8
Construction	23/24	16/14	40/39	4/3	*/1	Mining 6/5	11/14
Consulting	16/22	16/20	61/46	1/2	1/*		5/10
Electronics-Electrical	57/55	26/28	*/*	5/6	6/5	Aerospace 5/4	2/1
Machinery	14/14	68/64	2/1	2/3	7/10		7/8
Metals	8/9	42/41	9/8	8/9	10/9	Metallurgical 17/8	6/16 (2)
Misc. Mfg.	9/15	35/28	7/7	35/37	13/12		1/1
Petroleum	14/9	22/22	10/9	34/39	2/1	Petroleum 14/16	4/4
Research & Development	61/75	21/16	*/*	6/3	*/*	Aerospace 6/*	6/6
Transportation Services	25/25	34/28	7/27	7/1	9/*	Aerospace 16/*	2/19 (3)
Utilities	63/67	20/18	10/7	2/2	2/2	Nuclear 2/3	1/1
Federal Government	36/36	18/13	29/40	2/1	2/1	Naval Arch 4/3	9/6
State Government	1/1	2/2	94/92	*/*	*/1		3/4
Local Government	7/11	2/6	87/73	1/7	*/1		3/2
Education	32/26	21/16	15/14	8/10	5/8	Aerospace 7/7	12/19

Note: Totals may not add to 100% due to rounding.
(1) All replies weighted in proportion to numbers of hires.
(2) Aerospace 9 in 1976
(3) Metallurgical 12 in 1976
* Less than 1%

The overall picture for all employers of engineers is one of surprising stability in the demand for all specialties. There is a hint that the glamor of the aerospace engineering curricula is not matched by plans for hiring proportionately greater numbers of its graduates. On the other hand, there is no reason to predict the early demise of curricula such as mining and petroleum engineering, which have suffered hard times in recent years. The small growth in the percentage of demand for industrial engineers is perhaps surprising in view of the current popularity of systems analysis, quality control, statistical techniques, and computer applications, all of which are well covered by the industrial engineering curricula. The continued trend toward engineering as basic training for modern industrial management would also seem to favor the industrial engineering curricula more than this survey would indicate.

H. FIRMNESS OF DEMAND

HOW FIRM IS THE DEMAND FOR SPECIFIC CURRICULA?

This question is always a matter of great interest to engineers looking for positions outside the traditional curricula in which they were educated. To shed some light on this matter, the 1966 survey for the first time included a question asking to what extent expected openings might be filled by graduates of different curricula. For all respondents, the answer was that about one third of the vacancies are for graduates of specific curricula, another third would accept graduates of two or more engineering curricula, while the remaining third could be filled by various combinations of engineering graduates or others.

Activities which reported a particularly strong need for graduates of specific engineering curricula were local government, 74%; utilities, 68%; education, 67%; state government, 63%; federal government, 60%; petroleum, 53%; and chemicals, 52%.

Machinery, 48% and electronics, 44%, were most willing to accept graduates of several engineering curricula interchangeably. Other industries with a high degree of engineering flexibility were machinery, transportation, research and development, and aerospace.

When it came to accepting either an engineer or a scientist, the metals industry led with 29%. Research and development with 28% was close behind.

No industry reported a plurality in favor of accepting engineering graduates interchangeably with other non-science graduates, but transportation showed a high percentage - 32% - of flexibility in this area.

Engineers, graduate or nongraduate, were acceptable for 38% of the openings in construction. State government was also quite high with 31% in this category, and consulting reported 21%. Chemicals, education, research and development, and utilities indicated a negligible interest in accepting nongraduates.

Overall, the aerospace industry shows the greatest degree of flexibility, with only 18% of its jobs requiring graduates of specific engineering curricula, and with non-engineering graduates acceptable in 51% or all positions. Other industries willing to hire large numbers of non-engineers to do engineering work were construction, 58%; and metals, 59%.

Detailed replies for all activities are shown in Table 8 on page 47.

I. SEPARATIONS

WHAT WAS THE SEPARATION RATE FOR ENGINEERS?

In previous surveys since 1960 there has been very little variation in separation rates, with maximum rates of 9.9% and 9.0% respectively. This year's findings show generally lower rates across the board. For all respondents (unadjusted) the overall rates were:

1964	6.2%
1965	6.5%
1966 (est.)	5.9%

Rates for all activities are shown in Table 9 on page 48.

WHAT WERE THE CAUSES FOR SEPARATIONS?

Reasons for separation are categorized as: death, retirement, resignation, discharge, layoff, armed forces, and other. As usual, resignations are the most common single cause. This year, resignations are down from 6.0% in 1963 to 4.3% in 1965. No other single factor accounts for as much as 1% of the total, but all causes seem to show lower rates this year. Discharges

TABLE 8

Degree to Which 1966 Openings Could Be Filled By People With Various Alternative Educational Qualifications

ACTIVITY (1)	Graduate Engineer Specific Curriculum	Graduate Engineer Choice of Two or more Curricula	Graduate Engineer, Physical Scientist, or Mathematician	Graduate Engineer or other Curriculum	Graduate or Nongraduate Engineer
All Respondents	33%	31%	18%	7%	11%
All Industry	28	34	20	8	11
Aerospace	18	31	24	12	16
Chemical	52	32	12	4	1
Construction	30	12	10	10	38
Consulting	45	13	14	7	21
Electronics	24	44	20	6	6
Machinery	22	48	16	6	9
Metals	24	17	29	13	17
Misc. Mfg.	27	32	13	0	28
Petroleum	53	29	11	4	3
Research & Development	26	38	28	5	2
Transportation Services	20	39	5	32	4
Utilities	68	20	6	4	2
All Government	62	12	12	2	17
Federal Government	60	11	21	2	6
State Government	63	2	2	1	31
Local Government	74	5	2	2	16
Education	67	18	14	2	1

Note: Totals may not add to 100% due to rounding.
(1) All replies weighted in proportion to numbers of openings.

TABLE 9
ENGINEERING SEPARATIONS - 1965

ACTIVITY	Returns	Engineering Employment Dec. 31, 1965	Engineering Separations							
				Reasons for Separation						
			Total Separations	Death	Retire-ment	Resig-nation	Dis-charged	Lay-offs	Armed Forces	Other
ll Respondents	490	170,987	6.5%	0.2%	0.6%	4.3%	0.3%	0.2%	0.2%	0.8%
ll Industry	324	143,217	6.3	0.1	0.5	4.3	0.3	0.2	0.2	0.7
Aerospace	15	37,907	10.2	0.1	0.1	7.4	0.2	0.4	0.1	1.9
Chemical	16	12,759	4.4	0.2	0.7	2.9	*	*	0.3	0.2
Construction	27	2,383	11.3	0.2	0.4	8.9	1.0	0.8	*	*
Consulting	66	3,436	13.2	0.3	0.7	8.6	1.6	1.5	0.3	0.2
Electronics-Electrical	35	47,723	3.9	*	0.3	2.6	0.3	*	0.4	0.2
Machinery	33	5,330	4.3	*	0.2	3.0	0.4	0.1	0.1	0.4
Metals	18	5,954	1.4	*	0.2	0.9	*	*	*	*
Misc. Mfg.	19	2,911	6.8	*	0.7	4.8	0.5	*	*	0.9
Petroleum	14	7,738	6.8	0.3	0.7	4.5	0.6	*	0.2	0.5
Research & Development	14	6,078	7.2	0.2	0.7	4.2	0.9	0.4	*	0.9
Transportation Services	12	707	4.5	0.3	0.8	2.1	0.1	*	*	1.1
Utilities	55	10,291	5.2	0.4	2.0	2.2	*	*	0.2	0.4
ll Government	63	21,619	7.3	0.4	1.8	4.0	*	*	0.2	0.9
Federal	20	11,494	7.0	0.3	2.3	2.8	*	*	0.1	1.3
State	13	8,040	7.5	0.5	1.1	5.6	*	*	0.3	*
Local	30	2,085	7.1	0.5	1.8	4.0	*	*	*	0.6
ucation	103	6,151	8.4	0.3	0.8	5.9	0.1	*	*	1.2

Note: Figures may not add to 100% due to rounding
* Less than 0.1%

and layoffs combined are down from 1.7% in 1963 to 0.5% in 1965. Armed forces calls, not tallied in earlier surveys, accounted for only 0.2% of the overall rate, indicating that the draft has not yet created a major engineering manpower problem. In view of the general engineering employment demand, however, even the small additional requirement imposed by armed forces needs can put a severe squeeze on employers whose businesses are not essential to national defense.

Among the various employment activities, consulting, construction, and aerospace had the highest overall separation rates and the most resignations. Layoffs were highest in research and development and aerospace in 1964, but both of these dropped below consulting in 1965. Deaths and retirements were, as expected, highest in such established activities as government, utilities, and transportation. See Table 9 for the 1965 percentages, and Appendix Tables VII and VIII for details of the 1964 and 1965 findings.

6 The Demand for Technicians

A. TECHNICIAN EMPLOYMENT

HOW DID TECHNICIAN EMPLOYMENT GROW IN THE LAST TWO YEARS?

Technician employment grew even faster than that of engineers between 1964 and 1966. The adjusted figures (see Appendix page 73 for methodology) for total employment, all industry, all government are:

Increase in Total Technician Employment

	1964-1965	1965-1966
All Employers	10.8%	15.2%
All Industry	13.5%	19.1%
All Government	4.0%	4.5%

The chemical and electronics industries were the greatest gainers, with increases each year between 22% and 25%. Metals, petroleum, utilities, federal, and state government were consistently low. All other activities showed substantial growth rates in technician employment for one or both of the periods in question, as shown in Table 10 below. Basic data for technicians are shown in Appendix Tables IX, X, and XI.

In comparison with the figures for engineers (see Table 1), the situation for technicians was definitely more favorable in chemicals and electronics, and somewhat more favorable in consulting, research and development, transportation, and local government. Engineers did better in education, but in other activities there was no clear trend either way, making liberal allowance for possible inaccuracies in the statistics.

The current rates of technician employment growth compare

TABLE 10

Growth in Technician Employment, 1964-1966

ACTIVITY	Returns *	1964 Actual	1965 Actual	1965 % Increase	1966 Estimated	1966 % Increase
Aerospace	12	10,630	11,925	12.2	13,462	12.9
Chemical	9	501	617	23.2	756	22.5
Construction	13	127	156	22.8	170	9.0
Consulting	53	1,564	1,846	18.0	2,023	9.6
Electronics-Electrical	27	8,477	10,585	24.9	13,219	24.8
Machinery	30	1,509	1,580	4.7	1,814	14.8
Metals	16	2,806	2,880	2.6	2,998	4.1
Misc. Mfg.	17	1,591	1,676	5.3	1,792	6.9
Petroleum	12	2,588	2,622	1.3	2,651	1.1
Research & Development	14	3,479	3,874	11.3	4,349	12.3
Transportation Services	6	97	118	21.7	136	15.3
Utilities	44	5,610	5,696	1.5	5,930	4.1
Federal Government	19	8,601	8,897	3.4	9,064	1.9
State Government	12	13,793	14,106	2.3	14,327	1.6
Local Government	24	794	872	9.8	1,032	18.4
Education	78	1,781	1,856	4.2	1,958	5.5

* Respondents who do not employ technicians have been excluded

favorably with those reported in our previous survey, as follows:

Technician Employment

Year	Returns	Jan. 1	Dec. 31	Growth
1962	369	58,315	62,101	6.5%
1963	369	62,101	64,678	4.1%
1964	386	61,904	63,954	3.3% *
1965	386	63,954	69,306	8.4% *

*Unadjusted figures. Adjusted values are 10.8% and 15.2% respectively. (See page 73).

B. RECRUITMENT

HOW DIFFICULT WAS TECHNICIAN RECRUITMENT THIS YEAR?

As with engineers, the recruitment of technicians appears to have been much more difficult in 1966 than in 1965. (See Table 11 on page 54.) The only areas reporting less difficulty in any category were the petroleum industry and state government. In petroleum the weakness was mainly in experienced technician hires, while in state government it showed in all categories.

Overall, experienced technicians were harder to recruit than new graduates, but this situation was reversed in chemicals, consulting, research and development, utilities, federal, and local governments. The aerospace and construction industries found greater difficulty in recruiting experienced technicians and trainees, but not technical school graduates. Apparently graduates of such institutions are more oriented to these kinds of work and more inclined to seek out openings in these industries. The demand for both new graduates and experienced technicians was particularly high in electronics, and reasonably high in the other activities not already mentioned.

The general difficulty in recruiting also extended into the category of trainees for company training or upgrading, although the pattern varied widely among industries. If we assume that the proportion of people with the ability to be upgraded is more or less the same in all activities, it would appear that those industries which depended heavily on internal programs to upgrade their employees into technician jobs would have the most difficulty in recruiting, since they would soon skim off the cream of the crop. Aerospace, construction, consulting, machinery, transportation, utilities, and the federal government all fit this pattern, and therefore offer the best opportunities

TABLE 11

1966 Technician Recruitment Compared to 1965

How Respondents Reported Degree of Difficulty in Recruiting Technicians

ACTIVITY (2)	Number of Respondents(1)	Number of Hires	New Technical Institute Graduates			Experienced Technicians			Trainees for Upgrading		
			More Difficult	Same	Less Difficult	More Difficult	Same	Less Difficult	More Difficult	Same	Less Difficult
All Respondents	366	11,281	62%	37%	*	77%	20%	2%	60%	37%	3%
Aerospace	14	2,696	28	72	0	95	5	0	92	8	0
Chemical	8	181	100	0	0	38	62	0	25	65	0
Construction	12	44	36	64	0	98	2	0	98	2	0
Consulting	52	915	77	23	*	75	24	*	71	29	*
Electronics-Electrical	28	2,768	98	2	0	98	2	0	55	45	0
Machinery	31	352	48	52	0	69	31	0	71	29	0
Metals	15	110	66	34	0	93	7	0	14	86	0
Misc. Mfg.	15	253	45	55	0	90	10	0	19	81	0
Petroleum	12	74	21	79	0	20	43	36	4	96	0
Research & Development	14	541	93	7	0	42	58	0	7	93	0
Transportation Services	6	30	63	37	0	63	37	0	63	37	0
Utilities	42	512	66	34	0	58	42	0	62	30	7
Federal Government	17	750	61	39	0	9	92	0	84	16	0
State Government	12	1,649	44	49	8	74	12	15	27	58	15
Local Government	24	144	43	56	*	25	74	*	44	56	*
Education	64	262	25	74	*	63	36	2	37	61	1

Note: Percentages may not add to 100% due to rounding.
(1) Respondents who do not employ technicians have been excluded
(2) All replies weighted in proportion to numbers of technicians hired in 1965
* Less than 1%

for ambitious young people to upgrade themselves without formal education.

Conversely, the chemical, metals, petroleum, and research and development activities seem to want fewer trainees and to require more in the way of formal education or prior experience. The more complex nature of technician work in these industries may also be a factor predisposing them toward graduates of formal technological curricula.

Finally, it is of interest to note that although the growth of technician employment is greater than that of engineering, companies seem to find it easier to recruit technicians than engineers. This is undoubtedly due to the fact that there is a greater pool of manpower with the capability of performing technician jobs, and the presumption that this pool has not yet been subjected to the squeeze which has rendered engineering candidates so hard to find. Employers will probably find themselves forced to subdivide many of the functions they have traditionally considered as engineers' jobs, so that more of them can be handled by technicians. That the day when engineers were available to do technician work is fast vanishing in all areas of industry, is borne out by the findings of this survey.

C. GROWTH

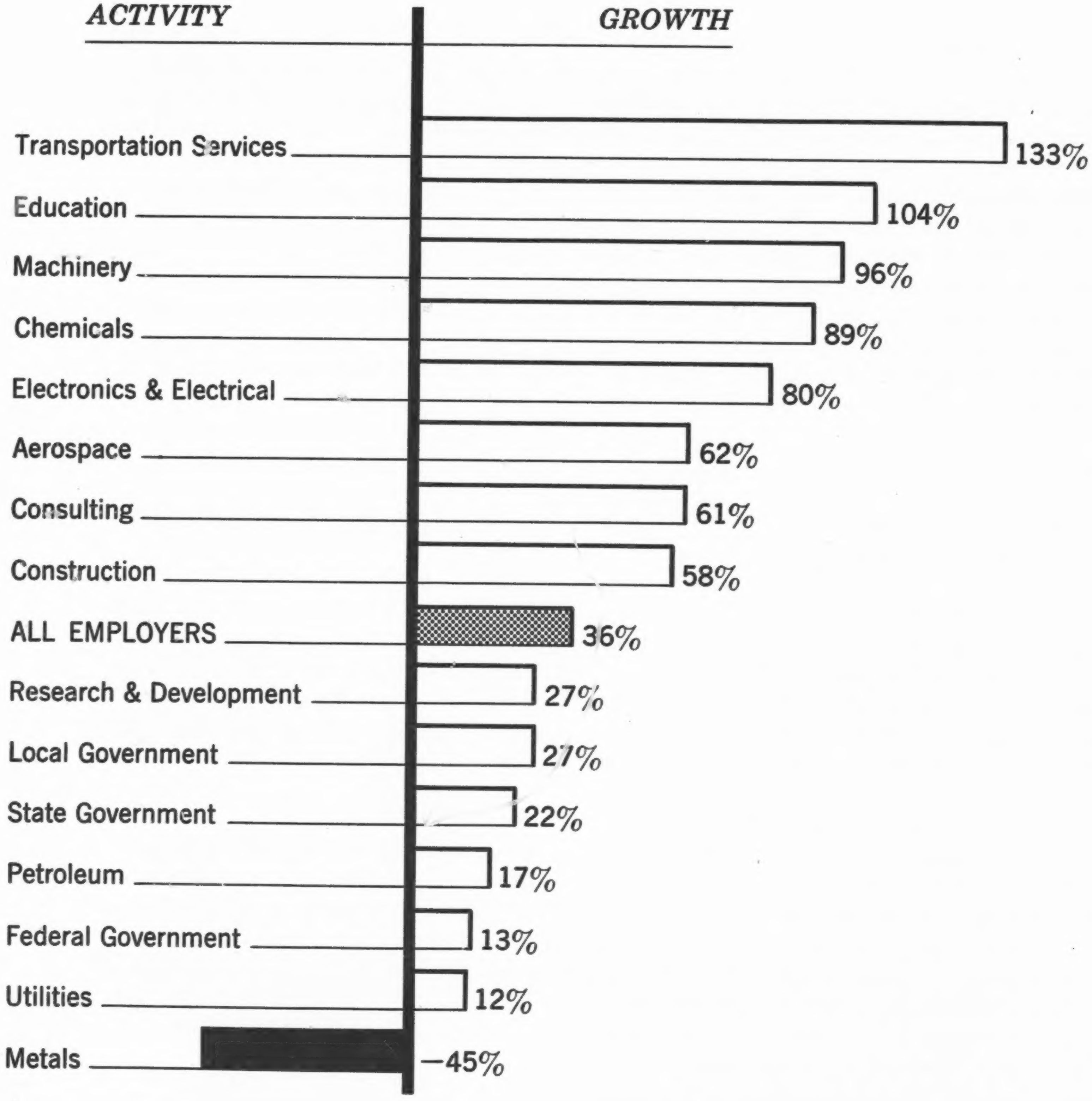
HOW DO EMPLOYERS ESTIMATE THE GROWTH OF TECHNICIAN EMPLOYMENT FOR THE NEXT DECADE?

Between 1965 and 1976, it is estimated that the total national employment of technicians will grow by 36%, or an average of 3.3% per year. (This figure was obtained by adjusting the returns for each activity as described in the Appendix, page 73.) It will be noted that this comes very close to the overall long-range increase predicted for engineers. (See page 31).

The same considerations apply to technician projections as to engineering - they are probably conservative beyond 1967. The figures for each activity are shown in Chart C on page 56, based on data in Appendix Table XII. Growth rates are anticipated to be particularly high in the transportation, electronics, machinery, and chemical industries and in education, and low in utilities, petroleum, research and development, and all levels of government. The metals industry respondents predict an actual reduction over the eleven-year period.

CHART C

PROJECTED GROWTH OF TECHNICIAN EMPLOYMENT, 1965–1976



D. TECHNICIAN RATIOS

HOW ARE THE RATIOS OF TECHNICIANS TO ENGINEERS AND SCIENTISTS CHANGING?

For all respondents in 1965, there were 42 technicians employed for every 100 engineers and scientists. This compares with a ratio of 38:100 in the 1964 survey.

Within industries changes may be due as much to variations in the sample as to fundamental changes in employment patterns. Details for 1965 and for projections in 1976 are given in Appendix Table XIII, but should be used with caution.

As noted in paragraph F below, employers generally expect the ratio of technicians to engineers and scientists to increase. In view of the rapidly changing picture relative to the utilization of technicians, this qualitative judgment is probably a better indication of future trends than the numerical estimates of future technician employment.

E. GRADUATES

WHAT ARE THE LONG-RANGE PROSPECTS FOR TECHNICAL SCHOOL GRADUATES?

As with engineers, those with formal education appear to have a much better chance of obtaining and keeping jobs. In years which show reduced overall hiring, technical institute graduate hires generally continue to gain at the expense of other categories. Thus an analysis of returns showed a small overall decrease in hires of new graduates.

The figures for 1964 through 1976 are shown in Table 12. (Page 58). The increases are so great as to make percentages meaningless because of the low base figures for 1964. The picture adds up to an overwhelming demand for technical school graduates in practically all activities, with the greatest expansion in education, chemicals, federal government, electronics, and consulting. Increases in utilities, research and development, and aerospace will be more modest percentagewise, but this may be due to the fact that utilization of technicians in these industries is already high, whereas the others are just beginning to open up significant numbers of positions for the technical school graduate.

TABLE 12

New Hires Of Technical Institute Graduates

ACTIVITY	Returns	1964 Actual	1965 Actual	1966 Estimated	1967 Projected	1971 Projected	1976 Projected
Aerospace	13	402	564	685	784	923	1,292
Chemical	6	29	45	63	189	306	485
Construction	9	2	11	7	25	32	32
Consulting	37	15	36	42	120	147	189
Electronics-Electrical	20	305	582	553	617	801	1,047
Machinery	25	34	67	135	185	298	421
Metals	10	7	15	24	33	38	40
Misc. Mfg.	8	17	39	58	49	94	133
Petroleum	8	33	32	28	89	126	153
Research & Development	9	74	150	206	172	178	228
Transportation Services	3	0	0	6	10	13	19
Utilities	31	154	210	179	321	296	326
Federal Government	10	18	31	38	123	237	291
State Government	9	49	70	95	157	237	344
Local Government	17	17	8	72	104	121	128
Education	47	6	12	15	74	136	198

F. COMPOSITION

HOW WILL THE COMPOSITION OF TECHNICIAN STAFFS CHANGE IN THE FUTURE?

Employers would obviously prefer to increase the proportion of technical school graduates among their staffs of technicians, as indicated by the projected increase in hires discussed in the preceding section. This is confirmed by replies to three questions, in which a large majority of employers indicated their belief that the proportion of technicians to engineers and scientists will increase, the number of technicians trained by the company will increase, and the proportion of technical institute graduates among new hires will increase. The replies for each activity are summarized in Table 13 on page 60.

62% of the respondents (weighted in proportion to the number of technicians employed) think that the ratio of technicians to engineers and scientists will increase, while 35% think it will stay about the same. Industries which appear to anticipate the greatest increase are chemicals, electronics and metals. The least change is predicted in research and development, but construction, federal government, and local government are also low.

Respondents also anticipate an increase in the number of technicians trained within their organizations, with electronics, aerospace, and the federal government showing the greatest tendency in this direction. Research and development and metals expect little expansion of this source of technicians.

Practically all activities expect to hire an increased proportion of technical institute graduates in the next decade. The federal government, transportation, and construction are the areas of greatest weakness.

In a few cases the replies to this section of the questionnaire may appear to be inconsistent with other parts of the report. This difficulty is more apparent than real. It should be remembered that changes in ratios or proportions do not necessarily mean similar changes in absolute numbers. Any interpretation of these trends must therefore include a consideration of the actual numbers employed or projected as well as the apparent direction and rate of change.

In all probability, the degree to which these predictions will be realized will depend more on the available supply of new graduates than on the desires of the employers.

TABLE 13

FUTURE TRENDS

Percent Of Respondents Who Believe The Composition Of Technician Staffs Will Change As Indicated Over The Next Decade

ACTIVITY (1)	The Proportion of Technicians to Engineers and Scientists Will			The Number of Technicians Trained By Your Organization Will			The Proportion of New Hires Who Are Technical Institute Graduates Will		
	Increase	Stay the Same	Decrease	Increase	Stay the Same	Decrease	Increase	Stay the Same	Decrease
All Respondents	62%	35%	4%	70%	25%	5%	81%	16%	3%
All Industry	68	31	1	68	30	2	91	9	*
Aerospace	65	35	*	84	16	*	98	2	*
Chemical	97	3	*	43	57	*	97	*	3
Construction	34	63	3	46	54	*	47	53	*
Consulting	45	54	1	74	26	*	80	20	*
Electronics-Electrical	96	3	1	96	4	*	98	2	*
Machinery	72	23	5	65	35	*	82	18	*
Metals	94	5	*	15	85	*	91	9	*
Misc. Mfg.	36	64	*	76	8	16	69	28	4
Petroleum	71	29	*	29	71	*	99	1	*
Research & Development	3	90	7	14	86	*	76	24	*
Transportation Services	63	34	3	79	18	3	40	60	*
Utilities	79	20	*	79	14	7	83	16	*
All Government	52	41	8	73	16	11	60	31	9
Federal Government	30	69	1	82	18	*	35	65	*
State Government	64	24	12	69	12	19	81	*	19
Local Government	40	57	3	44	54	2	70	30	*
Education	70	27	3	77	15	8	85	15	*

(1) All replies weighted in proportion to numbers of technicians employed.
* Less than 1%
Note: Individual percentages may not total 100% due to rounding.

G. SEPARATIONS

WHAT WAS THE SEPARATION RATE FOR TECHNICIANS?

The overall rates for all respondents, unadjusted, were as follows for this survey:

1964	7.5%
1965	9.0%
1966 (est.)	7.8%

These are consistently higher than the respective rates for engineers, but definitely lower than the 1964 survey figures. This is thus one more reflection of the improved employment picture for 1965-1966, as noted elsewhere in this survey. Rates for all activities are shown in Table 14 on the next page.

WHAT WERE THE CAUSES FOR SEPARATION?

Of the seven reasons for separation, resignation was the most prominent, accounting for about two-thirds of all separations. Discharges and layoffs were both very low in 1965. The layoff rate of 0.3% was in strong contrast to the 2.2% reported in 1963. Armed forces accounted for 0.5% of the technician separation rate, in contract to 0.2% for engineers.

Detailed returns for 1964 and 1965 will be found in Appendix Tables XIV and XV.

TABLE 14

TECHNICIAN SEPARATIONS - 1965

	Total Separation Rate	Reasons for Separation						
		Death	Retirement	Resignation	Discharged	Layoffs	Armed Forces	Other or not Specified
All Respondents	9.0%	0.2%	0.4%	5.9%	0.3%	0.3%	0.5%	1.4%
All Industry	9.3	0.1	0.2	6.0	0.3	0.5	0.5	1.6
Aerospace	11.4	0.1	*	9.1	0.3	0.1	0.9	0.8
Chemical	10.5	*	0.3	8.9	0.3	0.3	0.6	*
Construction	9.6	*	*	9.6	3.8	*	*	*
Consulting	31.8	0.3	0.2	21.1	1.5	6.8	0.9	1.0
Electronics-Electrical	6.2	*	0.1	2.0	*	0.2	0.2	3.8
Machinery	17.7	0.4	0.4	12.2	1.5	0.4	2.0	0.8
Metals	2.5	*	0.1	1.5	0.2	0.4	*	0.2
Miscellaneous Mfg.	8.5	*	*	7.0	0.4	0.4	0.5	*
Petroleum	8.4	0.2	0.8	6.2	0.3	0.5	0.2	0.1
Research & Development	4.2	0.1	0.1	2.8	0.2	0.4	0.1	0.4
Transportation Services	7.6	*	*	2.5	*	*	*	5.1
Utilities	8.1	0.4	0.7	4.0	0.2	*	0.4	2.4
All Government	8.4	0.2	0.8	5.7	0.4	*	0.6	2.9
Federal Government	6.0	0.2	1.8	2.0	0.5	0.1	0.1	1.3
State Government	9.8	0.2	0.2	8.0	0.3	*	0.9	0.3
Local Government	10.8	0.8	1.0	6.9	0.1	*	0.9	0.9
Education	11.0	0.3	0.2	5.8	0.4	*	*	4.4

Note: Percentages by reasons for separation may not add exactly to total separation rate due to rounding. See Appendix Table XV for actual numbers.

* Less than 0.1%

7

A Look at Supply

ENGINEERS

On the basis of census figures, the number of people reporting themselves as engineers would have risen to about 1,020,000 by the end of 1965. According to 1960 census data, 45% of this group do not hold a college degree. The Engineering Manpower Commission estimates that there are about 700,000 people doing engineering work of a college graduate level in the United States today, plus another 100,000 engineering graduates who are engaged in other occupations.

Because of World War II, the number of engineering bachelor's degree graduates dropped to less than 5,000 in 1945. Since then it has fluctuated rather dramatically, rising to 52,000 in 1950, dropping to 22,000 in 1954, increasing again to 38,000 in 1959, and hovering slightly below that number since then.

In recent years, the numbers of advanced degrees have increased markedly, at a rate of 11-12% per year. It has been estimated by the American Society for Engineering Education[1] that by 1976 the nation's engineering schools may be graduating 40,000 masters and 6,000 doctors annually.

In 1957, the percentage of college freshmen choosing engineering as a career, which had been rising until that time, underwent a sudden reversal in trend. From 23.2% in 1947 it has dropped steadily to 13.5% in 1965, and appears to be decreasing each year. This has coincided with a marked increase in the total number of students entering college, so that the absolute number of engineering freshmen has continued to grow except for two years in which a slight decrease was recorded.

---

[1] American Society for Engineering Education. *Goals of Engineering Education — The Preliminary Report.* Washington, D.C.: by the Society, October, 1965.

The situation is clouded by a tremendous expansion of community and junior colleges which do not offer engineering degrees, but whose graduates can transfer into regular curricula at the end of their second or third year. This has enabled the four-year schools to maintain junior and senior classes which at times are even larger than the previous year's sophomore enrollment. One effect of this has thus been to reduce the apparent attrition rate among engineering students.

The trend in attrition rates reversed itself in 1961, just four years after the shift in freshman enrollments. Prior to that year the rate of attrition had been gradually increasing. In 1961 the number of first degrees was only 45.6% of the number of freshman enrollments four years previously, but by 1965 it had risen to 53.5%, and appears to be still rising slowly. This so-called retention factor (the inverse of attrition) is becoming increasingly artificial. Although the number of degrees awarded is accurately known, the number of freshman enrollments four years earlier does not include pre-engineering students in the junior colleges and others which are not identified as engineering schools for purposes of the U.S. Office of Education surveys. Also, fewer students are receiving their degrees in four years. An American Society for Engineering Education[2] study showed that of students entering engineering in 1959, only 35.7% had graduated by 1963, whereas 48.7% had their degrees after six years.

This extension of the traditional four-year term for engineering education is significant in determining the supply of graduates actually available to start work. In essence, it represents a lengthening of the "educational pipeline" supplying engineers for the technical and professional manpower pool. Still another factor is operating to reduce the available supply, namely the trend toward advanced degrees. Many engineering educators are strongly in favor of establishing the master's degree as the minimum required for a well-rounded professional engineer. The percentage of bachelor's degree graduates who are continuing full-time study toward a master's or doctor's degree is increasing steadily, and in 1966 exceeded 25%. Thus one out of every four new graduates at the bachelor's level is effectively removed from the available work force. The two factors mentioned above, when applied to a fairly constant total number of engineering students, may have resulted in an actual reduction in the absolute number of graduates available between 1965 and 1966. This could explain much of the difficulty reported by employers in the 1966 recruitment situation.

---

[2] American Society for Engineering Education. *Factors Influencing Engineering Enrollment.* Washington, D.C. by the Society, October, 1965.

Based on the factors mentioned above, we have computed a new set of projections for engineering enrollments and degrees. These are shown in Table 15 and Charts D and E below. The net change over previous projections[3] is a reduction in future enrollments and bachelors degrees, and an increase in the master's and doctor's.

The actual supply of new engineering graduates available for employment in any given year will be substantially less than the total number of degrees awarded. For one thing, 26% of new bachelor's degree graduates in 1966 are continuing on to graduate study[4] without entering the labor market, and this percentage is expected to increase steadily in the future. Also, a high proportion of new master's and doctor's degrees currently awarded represent people who were formerly employed or who are studying in addition to holding jobs. Such people do not constitute new additions to the labor market, but are merely returning after having dropped out of the employment rolls.

In Table 16 on page 68 will be found the estimated numbers of new graduates at all levels actually entering the labor market in each year. For any given year, the number of bachelor's degrees has been reduced by the number continuing on in graduate school. It has been arbitrarily assumed that some of these will seek employment with master's degrees a year later, and the rest with doctor's degrees three years later. Those who fail to obtain advanced degrees will presumably look for jobs also, so no allowance has been made for attrition. Also, no reduction has been made for those engineering graduates who enter other occupations. This number has been variously estimated at 10-15%, but for this study it is assumed that most graduates will seek initial employment in engineering and shift jobs later on in their careers. Any small losses not accounted for are assumed to be offset by graduates of other curricula who accept engineering jobs.

Even on the basis on the generous assumptions noted above, Table 16 shows that there were fewer new graduates available in 1966 than in 1965, and the 1967 total will be almost the same.

Industrial employers should also note that a very high

---

[3] Engineering Manpower Commission of Engineers Joint Council. *The Placement of Engineering Graduates—1965*. New York: by the Council, October, 1965.

[4] Engineering Manpower Commission of Engineers Joint Council. *The Placement of Engineering Graduates—1966*. New York: by the Council, November,1966.

TABLE 15

Engineering Enrollments and Degrees

YEAR	FRESHMAN ENROLLMENTS	FIRST DEGREES	MASTER		DOCTOR	
			ENROLLMENTS	DEGREES	ENROLLMENTS	DEGREES
1953	60,478	24,164	18,323	3,635	3,001	592
1954	65,505	22,236	17,205	4,078	3,283	590
1955	72,825	22,589	18,482	4,379	3,163	599
1956	77,738	26,306	22,274	4,589	3,402	610
1957	78,757	31,211	23,840	5,093	4,180	596
1958	70,029	35,332	27,833	5,669	4,763	647
1959	67,704	38,134	29,355	6,615	5,643	714
1960	67,556	37,808	30,817	6,989	6,445	786
1961	67,575	35,860	32,054	7,977	7,869	943
1962	64,707	34,735	35,359	8,909	9,240	1,207
1963	65,740	33,458	37,781	9,460	10,827	1,378
1964	73,682	35,226	42,159	10,827	12,622	1,693
1965	79,872	36,691	44,208	12,246	13,947	2,124
projections						
1966	78,400	35,400	-	13,100	-	2,400
1967	76,700	36,600	-	14,100	-	2,700
1968	76,000	41,000	-	17,200	-	3,400
1969	77,600	45,000	-	20,100	-	4,000
1970	79,700	45,500	-	21,200	-	4,400
1971	82,100	44,800	-	22,100	-	4,700
1972	84,400	44,700	-	23,200	-	5,000
1973	86,200	45,800	-	24,900	-	5,500

CHART D

Engineering Freshman Enrollments and First Degrees

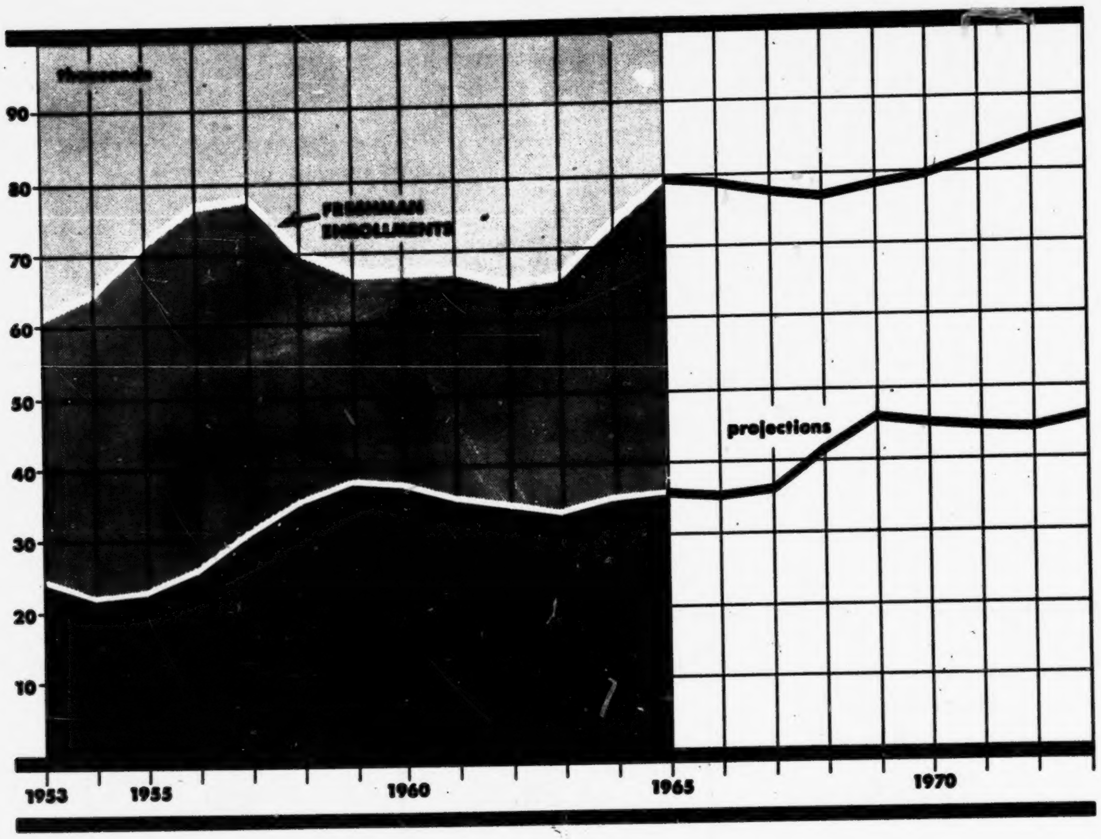
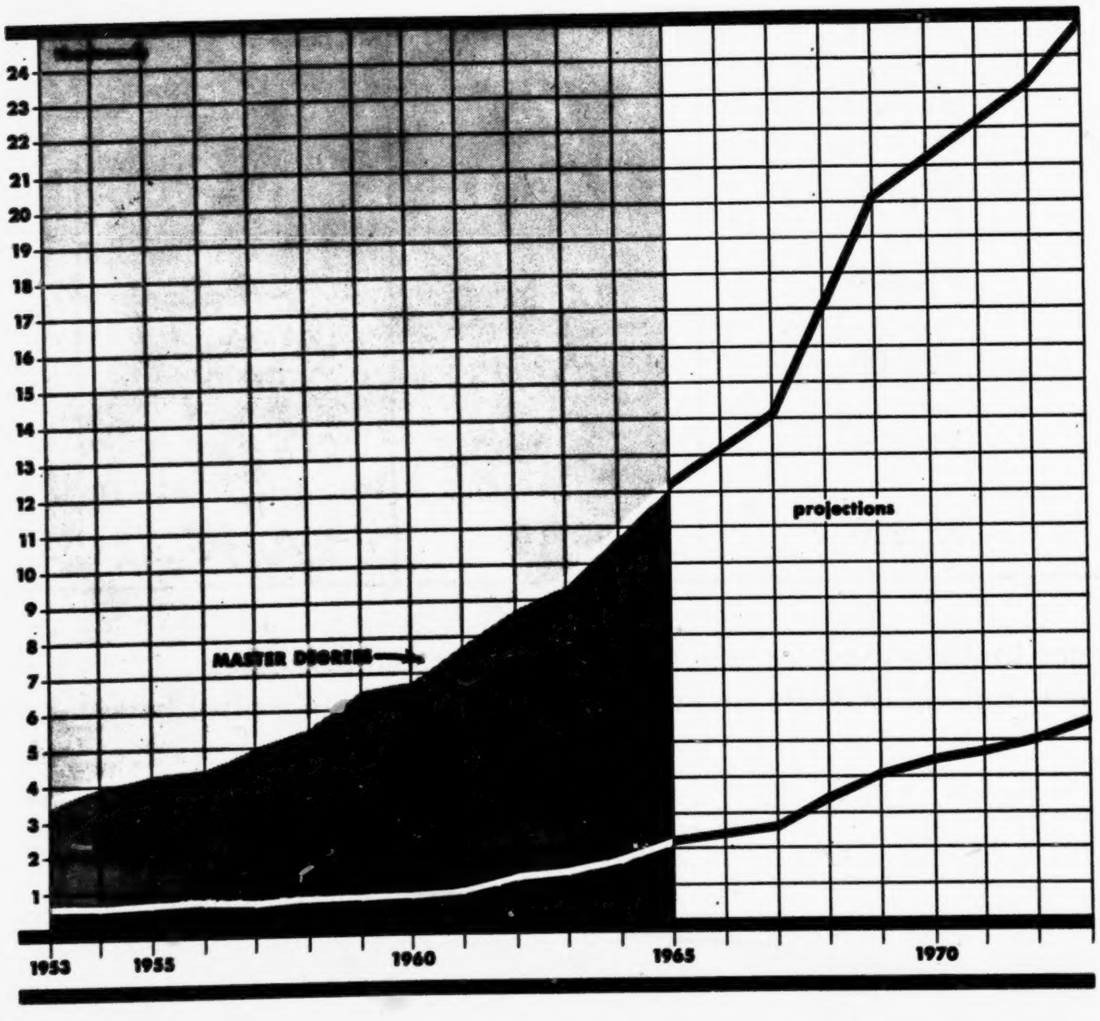


CHART E

Master's and Doctor's Degrees in Engineering



Source: Actual figures from U. S. Office of Education. Projections by Engineering Manpower Commission.

TABLE 16

New Graduate Engineers Available For Employment Each Year

	Degree Level			
Year	Bachelor (1)	Master (2)	Doctor (2)	Total
1965	27,500	6,800	800	35,100
1966	26,300	7,600	1,000	34,900
1967	26,900	7,400	1,200	35,500
1968	30,200	7,800	1,500	39,500
1969	32,900	9,100	1,700	43,700
1970	32,300	10,000	1,900	44,200
1971	31,500	10,000	2,300	43,800
1972	31,100	9,900	2,900	43,900
1973	31,700	9,900	3,200	44,800
1974	32,500	10,100	3,400	46,000

(1) Does not include those continuing full-time graduate studies.

(2) Does not include students who return for advanced study after having been employed.

percentage of graduates with advanced degrees prefer to seek teaching, research, or scientific positions. Thus as the percentage of advanced degrees increases, the percentage of all graduates available for recruiting by industry decreases.

There is therefore every expectation that industry faces a practically static supply of new bachelor's in engineering and only a moderate growth in the total engineering supply for the next decade. Because of the long lead time inherent in engineering education, it would take four to six years to initiate any significant change in these trends, even if strenuous efforts were started immediately. In the absence of any evidence of such efforts, there appears to be little chance of changing the supply picture in the near future.

In the face of high demand and limited supply, employers will have relatively few choices among alternative methods for meeting their needs for engineers. Probably the most effective results will be achieved by programs to improve the utilization of existing engineers, coupled with increased employment of technicians to perform the more repetitive technical functions. Another alternative would be to conduct active educational programs to upgrade subprofessionals to the equivalent of an engineering degree. Efforts to attract graduates of other curricula, mostly scientific, into engineering would probably have only limited success because of the relatively small numbers of candidates available, and the excellent employment opportunities available to these people in their own fields.

The increased employment of women as engineers is a long-range possibility, but would require basic changes in long-established and deeply-rooted cultural and educational patterns. The recruitment of more Negroes as engineering students is another possibility, but at best could produce only about a 10% increase (assuming that the factors influencing career choice and educational attrition would continue to apply unchanged) because Negroes constitute about that percentage of the total population.

In conclusion, it appears that the supply of engineers will continue to remain inadequate to meet the potential demand. For the individual graduate, this should be evidenced by a continuing increase in the number of job opportunities and in starting salaries offers at all degree levels.

TECHNICIANS

The situation with regard to formal technician educational programs is undergoing drastic change. In recent years a number of schools have developed four-year curricula leading to Bachelor of Technology degrees. At the same time, the ECPD accredited two-year technical institutes have continued to offer their regular programs in engineering technology.

Starting with the National Defense Education Act of 1958, federal legislation has stimulated the creation of a great many new vocational and technical programs at community colleges and other institutions. The Manpower Development and Training Act of 1962 and the Higher Education Facilities Act of 1963, added impetus to this expansion. Few, if any, of these new programs are accredited under the ECPD criteria. In addition to curricula terminating in a two-year Associate degree, many of these same institutions are offering pre-engineering transfer programs, often in cooperation with established four-year engineering schools. A survey by the Engineering Manpower Commission in mid-1966 disclosed more than 530 schools offering various technical programs with the following approximate numbers of students enrolled:

Program	Number of Students
Engineering Technicians	52,200
Physical Science Technicians	2,500
Industrial Technicians	22,600
Pre-engineering students	25,176
Bachelor of Engineering Technology Students	2,500
Bachelor of Industrial Technology Students	4,200

In addition to the foregoing, there were undoubtedly many more in non-responding institutions and in four-year liberal arts colleges which were not surveyed.

The U.S. Department of Labor, Bureau of Labor Statistics, recently issued its estimates on the annual supply of technicians[1] from 1963 to 1974 (see Table 17 on page 71).

Prior to 1962, the supply of technical institute graduates had remained fairly constant in the range of 15,000 to 17,000 per year. Table 17 indicates that the expansion should become apparent in 1966 and 1967. This dovetails quite well with the increased demand which has been predicted, both for technicians

---

[1] U.S. Department of Labor, Bureau of Labor Statistics, *Technician Manpower: Requirements, Resources and Training Needs.* Washington: Government Printing Office, 1966.

TABLE 17

New Entrants From Post-Secondary Preemployment Technician Training Programs, 1963-1974

Academic Year	Number Enrolled	Number Graduating	Number Entering Technician Occupations
1962-63	90,700	24,900	16,200
1963-64	99,900	27,500	17,900
1964-65	119,800	32,900	21,400
1965-66	153,000	42,800	27,800
1966-67	178,300	50,800	33,000
1967-68	191,600	55,600	36,100
1968-69	206,300	60,900	39,600
1969-70	222,900	66,900	43,500
1970-71	230,200	70,200	45,600
1971-72	240,100	74,400	48,400
1972-73	249,200	78,500	51,000
1973-74	257,100	82,300	53,500
Total 1963-74	2,239,000	667,700	434,000
Annual Average	186,200	55,600	36,200

Note: Parts may not add to total due to rounding.

Source: U.S. Department of Labor, Bureau of Labor Statistics, *Technician Manpower: Requirements, Resources and Training Needs.* Bulletin No. 1512. Washington: Government Printing Office, June 1966.

in their traditional occupations and for their movement into new areas made available because of the shortage of qualified engineers.

On the whole, however, projections of technician supply and demand must be tempered with caution because of the rapidly changing conditions under which technicians will be employed in the future, and the absence of consistent historical information. The definition of technical categories is still subject to great variability, and little standardization exists in job descriptions, so that comparisons both within and between industries are difficult. The next few years will undoubtedly produce both change and clarification in the technician picture, but today the crystal ball is still clouded.

8

Appendix

METHODOLOGY FOR ESTIMATING TOTAL DEMAND

The Bureau of Labor Statistics of the U.S. Department of Labor figures for national employment of engineers and technicians, by industry or other activity, were used to establish conversion factors by which replies to this survey were multiplied to arrive at overall estimates of demand.

In a number of cases, the BLS industry groupings did not correspond exactly with those used for this survey. Where this was the case, new factors were derived by combining or subdividing groupings in accordance with our best estimates of their contribution to the total employment of engineers or technicians, as applicable. By this means each activity was assigned a wieghting factor representing its proportion of national employment. Different factors were calculated for engineers and technicians, because the employment patterns differ for each group.

Once the weighting factors were established, they were used to compute a multiplier which was then applied to the replies to the questionnaire. The way this was done is illustrated by the following example:

Assume that an industry in 1965 employed 10% of all engineers in the country, and that this represented 100,000 engineers in the BLS totals. If replies were received from this industry covering 20,000 employed engineers, the multiplier of 5 would be used to convert the replies to a basis of 100,000. This same process would be followed for all activities. In the case of projected employment trends, this might yield the following hypothetical figures for the years under consideration:

Activity	Actual Replies 1965	Multiplier	Adjusted Replies 1965	Adjusted Replies 1967	Adjusted Replies 1976
A	20,000	5	100,000	120,000	150,000
B	1,000	10	10,000	15,000	18,000
C	10,000	2	20,000	18,000	22,000
Total	31,000		130,000	153,000	190,000

The total figures would then be used to calculate the growth in employment over the period in question. In the above case the growth from 1965 to 1976 would be 46%. We feel that this procedure is more accurate for estimating overall growth rates than a simple summation of all replies. However, we prefer not to use it to arrive at numerical estimates of total employment. Although Bureau of Labor Statistics figures have been used to establish the multipliers, they are based on a definition of engineering which includes a high percentage of nongraduates. Estimates of the total engineering population vary widely depending on the definition used, but the trends from year to year should be approximately the same regardless of the definition.

As a check on the validity of this method, an estimate of the total number of engineering graduates hired in 1965 was made by multiplying the questionnaire replies in the manner described. The result was in reasonable agreement with the number of engineering degrees awarded in 1965. In future surveys, this method will be refined and extended as appropriate.

APPENDIX TABLES

APPENDIX TABLE I

ENGINEERING: NEW HIRES, SEPARATIONS, AND TOTAL EMPLOYMENT - 1964

ACTIVITY	Returns	New Hires - 1964								Separations 1964	Net. Acc. 1964	Engineering Employment December 31, 1964		
		Graduates												
		Current Classes												
		B.S.	M.S.	Ph.D.	Total	Experienced	Total Graduates	Non Graduates	Total			Graduates	Non Grads	Total
All Respondents	490	4,372	842	354	6,198 (1)	6,542	12,740	1,631	14,371	9,816	4,555	136,264	23,261	159,525
All Industry	324	3,181	636	176	4,623 (1)	6,087	10,710	1,295	12,005	7,781	4,134	114,698	18,169	132,867
Aerospace	15	944	185	43	1,172	2,855	4,027	842	4,869	3,335	1,534	26,159	7,003	33,162
Chemical	16	398	84	47	529	402	931	14	945	616	325	11,811	433	12,244
Construction	27	34	6	1	41	258	299	118	417	130	287	1,841	260	2,101
Consulting	66	91	19	0	110	287	397	86	483	314	169	2,525	563	3,088
Electronics-Electrical	35	522	132	10	1,294 (1)	1,628	2,922	84	3,006	1,556	1,450	38,274	6,169	44,443
Machinery	33	247	24	1	272	79	351	53	404	108	296	4,176	670	4,846
Metals	18	27	8	2	37	65	102	19	121	63	58	5,648	209	5,857
Miscellaneous Mfg.	19	114	35	5	154	42	196	3	199	148	51	2,546	233	2,779
Petroleum	14	251	89	39	385	149	534	5	539	550	11	7,449	165	7,614
Research & Development	14	140	48	27	215	175	390	34	424	600	176	4,633	1,138	5,771
Transportation Services	12	13	1	0	14	20	34	16	50	26	24	410	273	683
Utilities	55	394	5	1	400	127	527	21	548	425	123	9,226	1,053	10,279
All Government	63	928	25	4	957	230	1,187	326	1,513	1,397	116	16,153	4,811	20,964
Federal Government	20	440	17	4	461	205	666	15	681	722	41	9,810	1,421	11,231
State Government	13	425	4	0	429	13	442	297	739	572	167	4,806	2,860	7,666
Local Government	30	63	4	0	67	12	79	14	93	103	10	1,537	530	2,067
Education	103	263	181	174	618	225	843	10	853	548	305	5,413	281	5,694

(1) 630 in current classes are not specified as to B.S., M.S., or Ph.D.

ENGINEERING: NEW HIRES, SEPARATIONS, AND TOTAL EMPLOYMENT - 1965

ACTIVITY	Returns	New Hires - 1965								Separations 1965	Net. Acc. 1965	Engineering Employment December 31, 1965		
		Graduates												
		Current Classes					Total Graduates	Non Graduates	Total					
		B.S.	M.S.	Ph.D.	Total	Experienced						Graduates	Non Grads	Total
All Respondents	490	5,957	1,309	447	8,608 (1)	10,606	19,214	3,415	22,629	11,467	11,462	145,263	25,724	170,987
All Industry	324	4,728	1,077	251	6,951 (1)	9,575	16,526	2,899	19,425	9,075	10,350	123,173	20,044	143,217
Aerospace	15	1,464	271	64	1,799	4,765	6,563	2,055	8,619	3,874	4,745	29,526	8,381	37,907
Chemical	16	561	132	73	766	300	1,066	8	1,074	559	515	12,307	452	12,759
Construction	27	63	11	1	75	275	350	202	552	270	282	2,085	298	2,383
Consulting	66	173	44	1	218	455	673	130	803	455	348	2,752	684	3,436
Electronics-Electrical	35	999	260	19	2,173 (1)	2,774	4,947	210	5,157	1,877	3,280	41,553	6,170	47,723
Machinery	33	356	35	4	395	151	546	168	714	230	484	4,376	954	5,330
Metals	18	53	10	3	66	82	148	32	180	83	97	5,723	231	5,954
Miscellaneous Mfg.	19	151	69	6	226	97	328	6	329	197	132	2,687	224	2,911
Petroleum	14	286	145	32	463	184	647	4	651	527	124	7,582	156	7,738
Research & Development	14	210	87	48	345	345	690	56	746	439	307	4,923	1,155	6,078
Transportation Services	12	22	0	0	22	27	49	7	56	32	24	428	279	707
Utilities	55	390	13	0	403	120	523	21	544	532	12	9,231	1,060	10,291
All Government (1)	63	936	39	7	982	747	1,729	501	2,230	1,575	655	16,173	5,446	21,619
Federal Government	20	514	36	7	557	483	1,040	28	1,068	805	263	10,068	1,426	11,494
State Government	13	329	3	0	332	215	547	429	976	602	374	4,577	3,463	8,040
Local Government	30	93	0	0	93	49	142	44	186	168	18	1,528	557	2,085
Education	103	293	193	189	675	284	959	15	974	517	457	5,917	5,917	6,151

(1) 895 in current classes are not specified as to B.S., M.S., or Ph.D.

APPENDIX TABLE III

ENGINEERING: ESTIMATES OF NEW HIRES, SEPARATIONS, AND TOTAL EMPLOYMENT - 1966

Activity	Returns	New Hires - 1966								Separations 1966	Net Acc. 1966	Engineering Employment December 31, 1966		
		Graduates						Non-grads.	Total			Graduates	Non-grads.	Total
		Current Classes				Experienced	Total Grads.							
		B.S.	M.S.	Ph.D.	Total									
All Respondents	490	6,477	1,434	577	9,488(1)	9,916	19,405	2,601	22,006	10,813	11,193	156,344	26,836	183,180
All Industry	324	5,335	1,176	333	7,845(1)	8,942	16,787	2,106	18,893	8,932	9,961	133,218	20,963	154,178
Aerospace	15	1,596	310	90	1,996	4,186	6,182	1,308	7,490	4,082	3,408	32,367	8,948	41,315
Chemical	16	753	163	98	1,014	415	1,429	16	1,445	563	882	13,213	428	13,641
Construction	27	68	20	4	92	252	344	228	572	304	268	2,368	283	2,651
Consulting	66	170	32	2	204	381	585	82	667	511	156	3,804	788	4,592
Electronics & Electrical	35	1,029	255	27	2,312(1)	2,705	5,017	148	5,165	1,806	3,359	44,944	6,138	51,082
Machinery	33	417	42	3	462	171	323	183	816	171	645	4,989	986	5,975
Metals	18	79	20	7	106	105	633	69	280	75	205	5,901	258	6,159
Miscellaneous Mfg.	19	172	76	8	256	67	211	1	324	141	183	2,805	289	3,094
Petroleum	14	313	134	31	478	200	678	3	681	504	177	7,761	154	7,915
Research & Development	14	293	108	62	463	308	771	42	813	350	463	5,359	1,182	6,541
Transportation Services	12	20	1	0	21	27	48	14	62	23	39	458	288	746
Utilities	55	425	15	1	441	125	566	12	578	402	176	9,246	1,221	10,467
All Government	63	825	56	7	888	667	1,555	475	2,030	1,439	591	16,625	5,585	22,210
Federal Government	20	429	34	7	470	433	903	95	998	742	256	10,320	1,430	11,750
State Government	13	273	10	0	283	208	491	352	843	605	238	4,695	3,583	8,278
Local Government	30	123	12	0	135	26	161	28	189	92	97	1,610	572	2,182
Education	103	317	202	237	756	307	1,063	20	1,083	442	641	6,504	288	6,792

(1) 1001 in current classes are not specified as to B.S., M.S., or Ph.D.

APPENDIX TABLE IV

NEW GRADUATE HIRES - BACHELOR'S DEGREE
1964 - 1976

Activity	Returns	1964 Actual	1965 Actual	1966 Est.	1967 Projected	1971 Projected	1976 Projected
Aerospace	14	942	1,439	1,596	1,911	2,340	3,122
Chemical	11	360	532	699	910	1,178	1,507
Construction	19	34	60	66	86	109	116
Consulting	52	63	137	140	185	209	260
Electronics & Electrical	27	297	652	634	712	916	1,177
Machinery	29	227	326	374	296	431	623
Metals	12	22	47	58	68	116	146
Miscellaneous Mfg.	14	104	139	160	252	365	376
Petroleum	12	256	282	309	426	536	583
Research & Development	11	135	209	254	243	249	285
Transportation Services	9	8	20	17	32	30	36
Utilities	44	353	327	332	436	369	383
Federal Government	17	408	476	404	523	681	731
State Government	10	406	307	251	395	450	597
Local Government	22	57	85	114	130	132	141
Education	87	236	270	292	446	612	720

APPENDIX TABLE V

ENGINEERING: HIRES BY CURRICULUM - 1966

Activity	Returns	Estimated Engrg. Hires Represented 1966	Estimated Number of Engineers to be Hired for Various Engineering Curricula													
			Electrical & Electronic	Mechanical	Civil, Architectural	Chemical	Industrial, Management	Aerospace	Metallurgical, Materials	Mining, Geological	Agricultural	Naval Arch. & Marine	Nuclear	Ceramic	Petroleum	Other
All Respondents	428	22,021	6,918	5,781	3,025	1,584	872	2,435	451	84	38	52	190	69	111	411
All Industry	287	19,087	6,238	5,393	1,654	1,487	802	2,342	392	71	31	5	134	67	97	374
Aerospace	14	8,473	2,194	2,385	775	187	278	2,098	241	22	0	0	89	62	0	142
Chemical	14	1,374	72	403	72	651	82	1	4	4	1	0	1	0	2	81
Construction	14	556	130	86	220	24	4	1	10	25	0	1	3	2	0	50
Consulting	59	661	107	108	402	9	7	3	2	2	0	1	9	0	2	9
Electronics & Electrical	34	4,737	2,678	1,252	4	215	289	174	38	0	0	0	22	2	0	63
Machinery	31	788	112	535	17	20	52	2	22	0	21	3	0	1	3	0
Metals	18	267	22	112	23	20	26	5	46	13	0	0	0	0	0	0
Miscellaneous Mfg.	18	255	22	89	18	89	33	0	4	0	0	0	0	0	0	0
Petroleum	14	621	88	134	60	210	14	0	12	4	2	0	0	0	90	7
Research & Development	14	778	473	164	6	49	4	49	11	0	0	0	0	0	0	22
Transportation Services	7	56	14	19	4	4	5	9	1	0	0	0	0	0	0	0
Utilities	50	521	326	106	53	9	8	0	1	1	7	0	10	0	0	0
All Government	56	1,983	374	192	1,227	22	22	30	14	9	2	42	22	0	7	20
Federal Government	17	971	351	175	284	19	17	30	13	0	2	42	22	0	7	9
State Government	13	829	11	13	783	1	4	0	1	7	0	0	0	0	0	9
Local Government	26	183	12	4	160	2	1	0	0	2	0	0	0	0	0	2
Education	85	951	306	196	144	75	48	63	45	4	5	5	34	0	7	17

APPENDIX TABLE VI

ENGINEERING: HIRES BY CURRICULUM - 1976

Activity	Returns	Estimated Engrg. Hires Represented 1976	Estimated Number of Engineers to be Hired for Various Engineering Curricula													
			Electrical & Electronic	Mechanical	Civil, Architectural	Chemical	Industrial, Management	Aerospace	Metallurgical, Materials	Mining, Geological	Agricultural	Naval Arch. & Marine	Nuclear	Ceramic	Petroleum	Other
All Respondents	428	198,442	64,395	50,210	24,553	18,126	8,339	17,479	3,794	904	381	621	2,241	487	1,647	5,265
All Industry	287	170,689	58,399	47,219	10,672	17,157	7,529	16,831	3,221	686	201	266	1,755	394	1,554	4,805
Aerospace	14	60,641	14,324	17,001	4,860	1,528	2,559	14,550	2,036	274	0	215	1,075	369	0	1,850
Chemical	14	17,431	1,528	5,151	838	7,310	954	14	167	39	14	0	14	0	36	1,366
Construction	14	3,476	834	503	1,365	94	35	2	65	180	0	10	10	2	0	376
Consulting	59	3,692	818	756	1,721	75	21	26	8	35	0	5	111	0	2	114
Electronics & Electrical	34	52,802	28,908	14,668	34	3,002	2,707	2,155	322	0	0	3	310	0	0	693
Machinery	31	5,481	761	3,522	65	160	546	0	193	0	151	14	0	13	51	5
Metals	18	912	82	370	76	86	81	80	75	41	2	19	0	0	0	0
Miscellaneous Mfg.	18	3,083	463	856	217	1,128	376	0	43	0	0	0	0	0	1,443	0
Petroleum	14	8,744	755	1,885	771	3,410	110	0	136	77	28	0	0	0	0	129
Research & Development	14	6,118	4,580	948	9	176	0	4	109	0	0	0	10	10	0	272
Transportation Services	7	489	122	136	134	6	2	0	61	14	0	0	14	0	0	0
Utilities	50	7,820	5,224	1,423	582	182	138	0	6	26	6	0	211	0	22	0
All Government	56	20,378	4,108	1,615	12,821	222	213	162	125	180	40	317	231	51	32	261
Federal Government	17	10,819	3,874	1,380	4,273	108	107	162	123	46	40	317	226	51	28	84
State Government	13	8,277	89	160	7,607	26	89	0	2	125	0	0	0	0	4	175
Local Government	26	1,277	145	75	941	88	17	0	0	9	0	0	5	0	0	2
Education	85	7,375	1,888	1,376	1,060	747	597	486	448	38	140	38	255	42	61	199

APPENDIX TABLE VII

ENGINEERING SEPARATIONS - 1964

Activity	Returns	Engineering Employment Dec.31, 1964	Total Separations	Engineering Separations						
				Reasons for Separations						
				Death	Retirement	Resignation	Discharged	Layoffs	Armed Forces	Other
All Respondents	490	159,525	9,816	277	877	6,077	371	1,065	329	820
All Industry	324	132,867	7,871	177	568	4,836	356	1,041	300	593
Aerospace	15	33,162	3,335	35	30	2,232	47	699	29	263
Chemical	13	12,244	616	33	83	374	5	30	56	35
Construction	27	2,101	130	2	15	71	22	18	2	0
Consulting	66	3,088	314	5	14	207	24	43	12	9
Electronics & Electrical	35	44,443	1,556	22	106	997	103	85	161	82
Machinery	33	4,846	108	2	9	76	8	1	6	6
Metals	18	5,857	63	3	6	45	5	3	0	1
Misc. Mfg.	19	2,779	148	6	6	103	24	1	2	6
Petroleum	14	7,614	550	19	75	319	65	2	17	53
Research & Development	14	5,771	600	7	48	234	47	159	2	103
Transportation Services	12	683	26	5	2	19	0	0	0	0
Utilities	55	10,279	425	38	174	159	6	0	13	35
All Government	63	20,964	1,397	86	265	814	9	20	27	176
Federal	20	11,231	722	47	172	296	7	20	17	163
State	13	7,666	572	29	64	467	2	0	10	0
Local	30	2,067	103	10	29	51	0	0	0	13
Education	103	5,694	548	14	44	427	6	4	2	51

APPENDIX TABLE VIII

ENGINEERING SEPARATIONS - 1965

ACTIVITY	Returns	Engineering Employment Dec. 31, 1965	Engineering Separations							
			Total Separations	Reasons for Separation						
				Death	Retirement	Resignation	Discharged	Lay-Offs	Armed Forces	Other
All Respondents	490	170,987	11,167	308	1,112	7,308	435	297	399	1,308
All Industry	324	143,217	9,075	203	672	6,090	417	292	357	1,044
Aerospace	15	37,907	3,874	50	30	2,808	65	150	48	723
Chemical	16	12,759	559	23	94	364	3	2	43	30
Construction	27	2,383	270	4	9	213	23	20	1	0
Consulting	66	3,436	455	10	24	297	54	52	10	8
Electronics & Electrical	35	47,723	1,877	30	166	1,215	126	31	212	92
Machinery	33	5,330	230	5	10	162	21	6	7	19
Metals	18	5,954	83	3	13	54	5	5	0	3
Misc. Mfg.	19	2,911	197	1	19	139	15	0	1	27
Petroleum	14	7,738	527	21	56	346	48	3	12	41
Research & Development	14	6,078	439	12	40	256	53	23	2	53
Transportation Services	12	707	32	2	6	15	1	0	0	8
Utilities	55	10,291	532	42	205	221	3	0	21	40
All Government	63	21,619	1,575	89	389	856	11	3	39	188
Federal	20	11,494	805	39	263	325	7	3	14	154
State	13	8,040	602	37	88	448	4	0	23	2
Local	30	2,085	168	13	38	83	0	0	2	14
Education	103	6,151	517	16	51	362	7	2	3	76

APPENDIX TABLE IX

TECHNICIANS: NEW HIRES, SEPARATIONS, AND TOTAL EMPLOYMENT - 1964

Activity	Returns	New Hires - 1964					Separations 1964	Net Acc. 1964	Technician Employment Dec.31, 1964
		New Grads.	Other School Sources	Up-graded	Expe-rienced	Total			
All Respondents	386	1,514	1,376	1,350	2,587	6,827	4,777	2,050	63,954
All Industry	253	1,412	1,125	845	2,114	5,496	3,349	2,147	38,979
Aerospace	12	407	376	224	524	1,531	1,240	291	10,630
Chemical	9	41	25	0	18	84	64	20	501
Construction	13	3	0	7	7	17	14	3	127
Consulting	53	21	74	36	542	673	413	260	1,564
Electronics & Electrical	27	588	359	312	568	1,827	627	1,200	8,477
Machinery	30	34	20	26	52	132	103	29	1,509
Metals	16	7	24	34	29	94	51	43	2,806
Miscellaneous Mfg.	17	18	65	31	30	144	120	24	1,591
Petroleum	12	33	39	22	150	244	174	70	2,588
Research & Development	14	75	19	61	149	304	287	17	3,479
Transportation Services	6	2	5	10	4	21	9	12	97
Utilities	44	183	119	82	41	425	247	178	5,610
All Government	55	96	190	502	413	1,201	1,297	-96	23,188
Federal Government	19	29	15	146	139	328	367	-39	8,601
State Government	12	49	168	326	245	788	861	-73	13,793
Local Government	24	18	7	31	29	85	69	16	794
Education	78	6	61	3	60	130	131	-1	1,781

APPENDIX TABLE X

TECHNICIANS: NEW HIRES, SEPARATIONS, AND TOTAL EMPLOYMENT - 1965

Activity	Returns	New Hires - 1965					Separations 1965	Net Acc. 1965	Technician Employment Dec.31,1965
		New Grads	Other School Sources	Up-graded	Experienced	Total			
All Respondents	386	2,303	2,365	2,178	4,823	11,669	6,254	5,415	69,306
All Industry	253	2,174	1,881	1,181	3,452	8,688	4,035	4,653	43,575
Aerospace	12	567	734	362	996	2,659	1,364	1,295	11,925
Chemical	9	88	58	7	28	181	65	116	617
Construction	13	11	0	13	20	44	15	29	156
Consulting	53	51	120	55	700	926	587	339	1,846
Electronics & Electrical	27	911	451	391	1,016	2,769	661	2,108	10,585
Machinery	30	68	112	47	123	350	279	71	1,580
Metals	16	16	39	45	45	145	71	74	2,880
Miscellaneous Mfg.	17	25	101	75	26	227	142	85	1,676
Petroleum	12	32	38	29	154	253	219	34	2,622
Research & Development	14	151	83	43	279	556	161	395	3,874
Transportation Services	6	2	7	15	6	30	9	21	118
Utilities	44	252	138	99	59	548	462	86	5,696
All Government	55	117	365	974	1,246	2,702	2,015	687	23,875
Federal Government	19	35	44	341	414	834	538	296	8,897
State Government	12	73	272	558	793	1,696	1,383	313	14,106
Local Government	24	9	49	75	39	172	94	78	872
Education	78	12	119	23	125	279	204	75	1,856

APPENDIX TABLE XI

TECHNICIANS: ESTIMATED NEW HIRES, SEPARATIONS AND TOTAL EMPLOYMENT - 1966

Activity	Returns	New Hires - 1966					Separa-tions 1966	Net Acc. 1966	Technician Employment Dec.31, 1966
		New Grads	Other School Sources	Up-graded	Expe-rienced	Total			
All Respondents	386	2,635	2,299	1,931	4,329	11,194	5,846	5,348	74,678
All Industry	253	2,412	1,750	1,171	3,130	8,463	3,765	4,698	48,297
Aerospace	12	697	876	449	1,202	3,224	1,687	1,537	13,462
Chemical	9	123	46	16	28	213	74	139	756
Construction	13	8	1	6	8	23	9	14	170
Consulting	53	57	80	45	381	563	413	150	2,023
Electronics & Electrical	27	815	236	311	903	2,265	631	1,634	13,219
Machinery	30	139	124	79	100	442	208	234	1,814
Metals	16	35	43	49	43	170	52	118	2,998
Miscellaneous Mfg.	17	61	84	31	21	197	81	116	1,792
Petroleum	12	28	24	20	124	196	167	29	2,651
Research & Development	14	211	106	41	266	624	147	475	4,349
Transportation Services	6	8	2	11	6	27	9	18	136
Utilities	44	230	128	113	48	519	285	234	5,930
All Government	55	208	426	746	1,079	2,459	1,911	548	24,423
Federal Government	19	41	33	175	272	521	354	167	9,064
State Government	12	95	325	526	735	1,681	1,460	221	14,327
Local Government	24	72	68	45	72	257	97	160	1,032
Education	78	15	123	14	120	272	170	102	1,958

APPENDIX TABLE XII

LONG RANGE GROWTH IN TECHNICIAN EMPLOYMENT TO 1976, BY ACTIVITY

Activity	Returns(1)	1965 Actual	1967 Projected	1971 Projected	1976 Projected	Total Percent Increase 1965-1976
Aerospace	14	11,844	14,370	16,060	19,205	62%
Chemical	5	225	271	347	425	89
Construction	11	111	149	218	176	58
Consulting	43	1,477	1,901	1,506	2,370	61
Electronics & Electrical	20	5,856	6,760	8,277	10,559	80
Machinery	26	1,471	1,734	2,203	2,879	96
Metals	11	662	323	346	362	(-45)
Miscellaneous Mfg.	10	1,162	721	919	1,132	(-3)
Petroleum	9	2,594	2,656	2,836	3,041	17
Research & Development	10	3,623	3,755	3,960	4,598	27
Transportation Services	5	103	127	170	240	133
Utilities	37	4,940	5,741	5,286	5,541	12
Federal Government	16	8,185	8,111	8,637	9,229	13
State Government	10	12,162	13,004	13,667	14,811	22
Local Government	21	703	900	957	895	27
Education	72	708	927	1,213	1,442	104

(1) Only respondents who replied to both current and long range questions are tabulated, consequently figures will not be identical with those in Table 10 or other tables.

APPENDIX TABLE XIII

RATIO OF TECHNICIANS TO ENGINEERS AND SCIENTISTS 1964 AND 1965

		Employment as of Dec. 31, 1964					Employment as of Dec. 31, 1965				
	Returns	En-gineers	Phys. Sci.	Total of Engrs. & Phys. Sci.	Techni-cians	Technicians per 100 Engrs. and Phys. Sci. 1964	En-gineers	Phys. Sci.	Total and Engrs. & Phys. Sci.	Technicians	Technicians per 100 Engrs.& Phys. Sci. - 1965
All Respondents	386	124,377	29,487	153,864	63,954	42	133,594	31,245	164,839	69,306	42
All Industry	253	98,553	23,261	121,814	38,979	32	106,775	24,931	131,706	43,575	33
Aerospace	12	25,427	2,930	28,357	10,630	37	28,686	3,658	32,526	11,925	37
Chemical	9	12,244	7,896	20,140	501	2	12,759	8,246	21,005	617	3
Construction	13	2,099	54	2,153	127	6	2,382	54	2,436	156	6
Consulting	53	3,070	246	3,316	1,564	47	3,417	278	3,695	1,846	50
Electronics & Electrical	27	21,809	4,599	26,408	8,477	32	24,400	5,345	29,745	10,585	36
Machinery	30	4,566	160	4,726	1,509	32	5,030	199	5,229	1,580	30
Metals	16	5,857	1,295	7,152	2,806	39	5,954	1,309	7,263	2,880	40
Miscellaneous Mfg.	17	1,498	697	2,195	1,591	72	1,583	309	1,892	1,676	89
Petroleum	12	5,567	3,204	8,771	2,588	30	5,634	3,166	8,800	2,622	30
Research & Development	14	5,771	2,000	7,771	3,479	45	6,078	2,811	8,259	3,874	47
Transportation Services	6	478	4	482	97	20	493	3	496	118	24
Utilities	44	10,167	176	10,343	5,610	54	10,177	183	10,360	5,696	55
All Government	55	20,607	5,189	25,796	23,188	90	21,162	5,214	26,376	23,875	91
Federal Government	19	11,231	5,039	16,270	8,601	53	11,494	5,064	16,558	8,897	54
State Government	12	7,374	63	7,437	13,793	185	7,644	62	7,706	14,106	183
Local Government	24	2,002	87	2,089	794	38	2,024	88	2,112	872	41
Education	78	5,217	1,037	6,254	1,787	29	5,657	1,100	6,757	1,856	27

APPENDIX TABLE XIV

TECHNICIANS: SEPARATIONS, 1964

Activity	Returns	Tech. Employed Dec. 31, 1964	Separations - 1964							
			Total Separations	Reasons for Separations						
				Death	Retirement	Resignation	Discharged	Lay-Offs	Armed Forces	Other
All Respondents	386	63,954	4,777	109	182	2,851	150	614	200	671
All Industry	253	38,979	3,349	63	96	1,885	109	599	124	473
Aerospace	12	10,630	1,240	14	13	898	32	213	59	11
Chemical	9	501	64	1	4	44	9	0	5	1
Construction	13	127	14	0	0	8	6	0	0	0
Consulting	53	1,564	413	5	0	235	17	112	15	29
Electronics & Electrical	27	8,473	624	6	9	173	2	108	9	320
Machinery	30	1,509	103	3	7	73	5	0	12	3
Metals	16	2,806	51	3	4	31	4	4	0	5
Miscellaneous Mfg.	17	1,591	120	2	0	68	4	1	3	42
Petroleum	12	2,588	174	3	22	115	13	14	5	2
Research & Development	14	3,479	287	3	5	114	5	147	6	7
Transportation Services	6	97	9	0	0	0	0	0	0	9
Utilities	44	5,610	247	23	32	126	12	0	10	44
All Government	55	23,188	1,297	43	81	883	38	15	75	162
Federal Government	19	8,601	367	16	40	153	10	12	3	133
State Government	12	13,793	861	20	28	693	26	3	70	21
Local Government	24	794	69	7	13	37	2	0	2	8
Education	78	1,781	131	3	5	83	3	0	1	36

APPENDIX TABLE XV

TECHNICIANS: SEPARATIONS, 1965

Activity	Returns	Tech. Employed Dec.31,1965	Separations - 1965							
			Total Separations	Reasons for Separations						
				Death	Retirement	Resignation	Discharged	Lay-Offs	Armed Forces	Other
All Respondents	386	69,306	6,254	118	305	4,064	238	223	361	945
All Industry	253	43,575	4,035	62	101	2,599	143	213	221	696
Aerospace	12	11,925	1,364	12	9	1,083	38	13	110	99
Chemical	9	617	65	0	2	55	2	2	4	0
Construction	13	156	15	0	0	9	6	0	0	0
Consulting	53	1,846	587	5	3	390	28	126	16	19
Electronics & Electrical	27	10,585	661	4	12	207	5	19	17	397
Machinery	30	1,580	279	6	6	193	24	7	31	12
Metals	16	2,880	71	1	4	44	5	11	0	6
Miscellaneous Mfg.	17	1,676	142	0	1	117	7	7	9	1
Petroleum	12	2,612	219	5	21	163	8	14	5	3
Research & Development	14	3,874	161	4	4	110	9	14	4	16
Transportation Services	6	118	9	0	0	3	0	0	0	6
Utilities	44	5,696	462	25	39	225	11	0	25	137
All Government	55	23,875	2,015	51	201	1,358	88	9	140	168
Federal Government	19	8,897	538	22	159	176	43	9	9	120
State Government	12	14,106	1,383	22	33	1,122	44	0	123	39
Local Government	24	872	94	7	9	60	1	0	8	9
Education	78	1,856	204	5	3	107	7	1	0	81

Demand for Engineers, Physical Scientists and Technicians In Industry and Government

---

A survey being conducted by
ENGINEERING MANPOWER COMMISSION
of Engineers Joint Council

Questionnaire Form

Confidential When Completed

PLEASE COMPLETE AND RETURN THIS FORM TO...

ENGINEERING MANPOWER COMMISSION
345 East 47th Street
New York, N. Y. 10017

...AS PROMPTLY AS POSSIBLE, BUT NOT LATER THAN MARCH 31, 1966

1. Reporting organization: Name..
Street Address..
City, State and Zip Code..
2. Name and title of person responsible for data: ....
3. Product or service of organization:..
4. Number of U. S. employees (best estimate as of January 1, 1966)...

In order to obtain authoritative information concerning the needs of industry and government for engineers, physical scientists and technicians, we would appreciate your help to the extent of furnishing the data requested in this questionnaire. Where exact data are not available, please furnish us with your most reliable estimate.

A complimentary copy of the results of this survey will be mailed to all participants. Only summary data will be published and participants will not be identified in any way.

CONSTITUENT SOCIETIES

AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
AMERICAN WATER WORKS ASSOCIATION
THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
AMERICAN SOCIETY FOR TESTING AND MATERIALS
THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
AMERICAN SOCIETY FOR METALS
THE SOCIETY OF AMERICAN MILITARY ENGINEERS
THE AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS

ASSOCIATE SOCIETIES

AMERICAN INSTITUTE OF CONSULTING ENGINEERS
AMERICAN INSTITUTE OF PLANT ENGINEERS
AMERICAN ASSOCIATION OF COST ENGINEERS
NATIONAL INSTITUTE OF CERAMIC ENGINEERS
SOCIETY OF WOMEN ENGINEERS
SOCIETY OF FIRE PROTECTION ENGINEERS

AFFILIATE SOCIETIES

AIR POLLUTION CONTROL ASSOCIATION
SOCIETY FOR NON-DESTRUCTIVE TESTING
INSTRUMENT SOCIETY OF AMERICA
AMERICAN SOCIETY FOR QUALITY CONTROL
CONSULTING ENGINEERS COUNCIL

REGIONAL AFFILIATE SOCIETIES

WESTERN SOCIETY OF ENGINEERS
MICHIGAN ENGINEERING SOCIETY
ENGINEERING SOCIETY OF CINCINNATI
LOUISIANA ENGINEERING SOCIETY
NORTH CAROLINA SOCIETY OF ENGINEERS
WASHINGTON SOCIETY OF ENGINEERS
ENGINEERING SOCIETIES OF NEW ENGLAND
HARTFORD ENGINEERS CLUB
SOUTH CAROLINA SOCIETY OF ENGINEERS
LOS ANGELES COUNCIL OF ENGINEERING SOCIETIES
AMERICAN MATERIAL HANDLING SOCIETY (NEW JERSEY CHAPTER)
CHINESE INSTITUTE OF ENGINEERS

②

PART ONE. EMPLOYMENT OF ENGINEERS

		ACTUAL 1964	ACTUAL 1965	EST. 1966
1. Number of engineers in your employ on December 31st:				
A. Engineering Graduates (employed in all activities, including supervision and management)	1			
B. Non-graduates*	2			
Total (1 + 2)	3			
II. Separations during the year of personnel in I above:				
A. Death	4			
B. Retirement	5			
C. Resignation	6			
D. Discharged	7			
E. Layoffs (not offset by reinstatements)	8			
F. Armed Forces (excess of departures over returns)	9			
G. Other (Specify)	10			
Total (4 + 5 + 6 + 7 + 8 + 9 + 10)	11			

		ACTUAL 1964	ACTUAL 1965	EST. 1966
III. Employment additions during the year:				
A. New engineering graduates (graduating during calendar year hired) Bachelor	12			
Master	13			
Doctor	14			
Total new engineering graduates (12 + 13 + 14)	15			
B. Experienced graduate engineers	16			
Total graduate engineers (15 + 16)	17			
C. Non-graduates* from all sources	18			
Total engineering additions (17 + 18)	19			
IV. Net accessions (19 minus 11):	20			

V. Current availability of engineers:

Based on your knowledge of current recruiting operations, please indicate the experience of your organization. Check one box on each line.

		MORE DIFFICULT	ABOUT THE SAME	LESS DIFFICULT
A. The recruitment of new engineering graduates (bachelor) is — than it was at this time last year.	A	☐	☐	☐
B. The recruitment of new graduate engineers (master) is — than it was at this time last year.	B	☐	☐	☐
C. The recruitment of new graduate engineers (doctor) is — than it was at this time last year.	C	☐	☐	☐
D. The recruitment of experienced engineering graduates is — than it was at this time last year.	D	☐	☐	☐
E. The recruitment of non-graduate engineers is — than it was at this time last year.	E	☐	☐	☐

*Non-graduates are defined as men lacking an engineering degree, but whose experience and training permit them to hold positions normally requiring such a degree.

③ PART TWO. EMPLOYMENT OF ENGINEERING AND PHYSICAL SCIENCE TECHNICIANS*

☐ ← Check if technicians are not employed by your organization.

		ACTUAL 1964	ACTUAL 1965	EST. 1966
I. Number of technicians* in your employ on December 31st:	1			
II. Separations during the year of personnel in I above:				
A. Death	2			
B. Retirement	3			
C. Resignation	4			
D. Discharged	5			
E. Layoffs (not offset by reinstatements)	6			
F. Armed Forces (excess of departures over returns)	7			
G. Other (Specify)	8			
Total (2 + 3 + 4 + 5 + 6 + 7 + 8)	9			

		ACTUAL 1964	ACTUAL 1965	EST. 1966
III. Employment additions during the year:				
A. New graduates of technical institutes**	10			
B. New hires from other school sources***	11			
C. Employees newly upgraded to technician status	12			
D. Experienced technicians	13			
Total technician additions (10 + 11 + 12 + 13)	14			
IV. Net accessions (14 minus 9)	15			

V. Current availability of technicians:

Based on your knowledge of current recruiting operations, please indicate the experience of your organization. Check one box on each line.

		MORE DIFFICULT	ABOUT THE SAME	LESS DIFFICULT
A. The recruitment of new graduates of technical institutes is — than it was at this time last year.	A	☐	☐	☐
B. The recruitment of experienced technicians is — than it was at this time last year.	B	☐	☐	☐
C. The recruitment of trainees capable of being upgraded to technician status is — than it was at this time last year.	C	☐	☐	☐

*Technicians are subprofessional assistants to engineers and physical scientists. They perform some, but not all, of the functions normally done by engineers or scientists. Their job requires the application of scientific principles to the performance of their work. They have technical education beyond high school of one or more years (normally two) full time, or equivalent industrial training and experience.

**Technical institute education usually embraces a two-year post high school program and may lead to an associate degree. Include graduates of technical programs in community colleges or other institutions.

***Include those hired on the basis of college or other school attendance short of graduation, but who have not had sufficient previous employment to be considered experienced technicians.

④

PART THREE. FLEXIBILITY OF DEMAND FOR ENGINEERS

I. Of the engineers you plan to hire in 1966 and 1976, please estimate the approximate percentages you would prefer in the following curricula (percentages should add up to 100%):

	1966	1976
A. Electrical and electronic		
B. Mechanical		
C. Civil, architectural		
D. Chemical		
E. Industrial, management		
F. Aerospace		
G. Metallurgical, materials		

	1966	1976
H. Mining, geological		
I. Agricultural		
J. Naval architecture and marine		
K. Nuclear		
L. Ceramic		
M. Petroleum		
N. Other		

II. Of the total number of engineering positions you would like to fill during 1966 (III C, line 8, page 2) please estimate the percentage which might alternatively be filled by the following (percentages should add up to 100%):

A. Must be graduate engineer with degree in a specific curriculum. ☐

B. Must be graduate engineer, choice of two or more curricula. ☐

C. Must be college graduate in engineering, physical science or math. ☐

D. Must be college graduate in engineering or other curriculum. ☐

E. May be either graduate or non-degree ("practical") engineer. ☐

⑤

PART FOUR. EMPLOYMENT OF PHYSICAL SCIENTISTS*

☐ ← Check if physical scientists are not employed by your organization.

		ACTUAL 1964	ACTUAL 1965	EST. 1966
I. Number of physical scientists* in your employ on December 31st:	1	☐	☐	☐
II. Separations during the year of personnel in I above:				
A. Death	2	☐	☐	☐
B. Retirement	3	☐	☐	☐
C. Resignation	4	☐	☐	☐
D. Discharged	5	☐	☐	☐
E. Layoffs (not offset by reinstatements)	6	☐	☐	☐
F. Armed Forces (excess of departures over returns)	7	☐	☐	☐
G. Other (Specify)	8	☐	☐	☐
Total (2 + 3 + 4 + 5 + 6 + 7 + 8)	9	☐	☐	☐
		ACTUAL 1964	ACTUAL 1965	EST. 1966
III. Employment additions during the year:				
A. New physical science graduates (graduating during calendar year hired) Bachelor	10	☐	☐	☐
Master	11	☐	☐	☐
Doctor	12	☐	☐	☐
Total new physical science graduates (10 + 11 + 12)	13	☐	☐	☐
B. Experienced physical scientists (all other)	14	☐	☐	☐
Total physical scientist additions (13 + 14)	15	☐	☐	☐
IV. Net accessions (15 minus 9):	16	☐	☐	☐

---

*For purposes of this questionnaire, the term "physical scientists" includes employees with a baccalaureate or higher degree in the fields of chemistry, physics, earth sciences, and mathematics.

⑥

PART FIVE. FUTURE TRENDS

Based on past experiences, projections or growth of technological activities, and volume of business, please estimate the general magnitude of employment:

		1967	1971	1976
1. Number of engineers to be in your employ at the end of the year (new hires plus those already employed)	HIGH	☐	☐	☐
	LOW	☐	☐	☐
2. Number of physical scientists to be in your employ at the end of the year (new hires plus those already employed)	HIGH	☐	☐	☐
	LOW	☐	☐	☐
3. Number of technicians who work with engineers and physical scientists to be in your employ at the end of the year (new hires plus those already employed)	HIGH	☐	☐	☐
	LOW	☐	☐	☐

		1967	1971	1976
4. Please estimate the number of new engineering graduates (bachelor only) to be hired during these years:	HIGH	☐	☐	☐
	LOW	☐	☐	☐
5. Please estimate the number of new graduates of technical institutes to be hired during these years:	HIGH	☐	☐	☐
	LOW	☐	☐	☐

During the next decade (1966–1976), please indicate the probable trends within your total staff. Check one box on each line.

	DECREASE	STAY THE SAME	INCREASE
6. The proportion of non-degree holding engineers will:	☐	☐	☐
7. The proportion of engineers whose highest degree is a bachelor's will:	☐	☐	☐
8. The proportion of engineers whose highest degree is a master's will:	☐	☐	☐
9. The proportion of engineers whose highest degree is a doctor's will:	☐	☐	☐
10. The proportion of technicians to engineers and physical scientists will:	☐	☐	☐
11. The number of technicians trained by your organization will:	☐	☐	☐
12. The proportion of new hires who are technical institute graduates will:	☐	☐	☐